Journal of the Royal Society of Arts

NO. 5004 FRIDAY, 24TH MAY, 1957 VOL. CV

FORTHCOMING MEETINGS

TUESDAY, 28TH MAY, at 5.15 p.m. COMMONWEALTH SECTION. THOMAS HOLLAND MEMORIAL LECTURE. '*The Imperial Institute*', by Kenneth G. Bradley, C.M.G., Director of the Imperial Institute. Sir Gilbert Rennie, G.B.E., K.C.M.G., M.C., High Commissioner for the Federation of Rhodesia and Nyasaland, will preside. (The paper will be illustrated by lantern slides. Tea will be served from 4.30 p.m.)

WEDNESDAY, 29TH MAY, at 2.30 p.m. '*The English Ballet*', by Dame Ninette de Valois, D.B.E., Director of the Royal Ballet. Sir Arthur Bliss, Master of the Queen's Musick, will preside. (Admission by special ticket only.)

THURSDAY, 6TH JUNE, at 5.15 p.m. SIR GEORGE BIRDWOOD MEMORIAL LECTURE. '*Romance and Poetry in Indian Painting*', by W. G. Archer, O.B.E., Keeper, Indian Section, Victoria and Albert Museum. Sir Herbert Read, D.S.O., M.C., Litt.D., M.A., President, Institute of Contemporary Art, will preside. (The lecture will be illustrated by lantern slides. Tea will be served from 4.30 p.m.)

Fellows are entitled to attend any of the Society's meetings without tickets (except where otherwise stated), and may also bring two guests. When they cannot accompany their guests, Fellows may give them special passes, books of which can be obtained on application to the Secretary.

CONFERENCE ON CAPITAL FOR SCIENTIFIC DEVELOPMENT

The Council of the Society, with the British Association for the Advancement of Science, has decided to hold a two-day Conference to discuss two major aspects of the Report on *Industry and Technical Progress*, of which an advance notice was published in the *Journal* for 15th March, 1957. This Report embodies the findings of the Science and Industry Committee which is sponsored by the Royal Society of Arts, the British Association and the Nuffield Foundation.

The Conference will take the form of two one-day sessions. The first session, under the Society's auspices and in the Society's House, will be held on 27th June and will consider the question of 'Capital for scientific development: the problems of its supply for Industry'. The second session, under the auspices of the British Association, will be held on 5th July at the University of Leeds, and will discuss the question of 'The supply of scientists and technologists for Industry'.

The President of the Board of Trade has agreed to open the Society's Conference on 27th June, and among the speakers expected are Sir Nutcombe Hume, Lord Piercy and Professors C. F. Carter and B. R. Williams, the joint authors of the Report, and in view of the importance of the subject for discussion it is hoped that as many as possible of the large firms and organizations who are being invited will be represented. A limited number of places will, however, be reserved for Fellows of the Society, and those who are interested in attending the Conference should apply to the Deputy Secretary by Monday, 3rd June.

INDUSTRIAL ART BURSARIES COMPETITIONS

EXHIBITION OF 1956 BURSARY DESIGNS

The Exhibition of winning and commended designs submitted in the 1956 Industrial Art Bursaries Competition was opened in the Library by Sir Colin Anderson, Hon.Des.R.C.A., on Tuesday, 21st May. A report of this official opening will, it is hoped, be included in the next issue of the *Journal*. The Exhibition will be open until 7th June, on Mondays to Fridays from 10 a.m. to 5.30 p.m., and on Saturdays from 10 a.m. to 12.30 p.m.

PUBLICATION OF 1956 COMPETITION REPORT

The Report on the 1956 Competition has now been published, and copies may be obtained from the Secretary without charge.

In addition to the list of awards, which was published in the *Journal* on 1st March last, the Report also contains particulars of the Tests set in each section, the reports and composition of the Juries, and a summary of the uses made of Bursaries in 1956 by previous Bursary winners. Illustrations of most of the winning designs, a number of which were reproduced in the *Journal* for 1st March last, are also included in the Report.

PARTICULARS OF 1957 COMPETITION

Full particulars of the competition to be held in 1957 are published with the Report on the 1956 Competition referred to above. The following sections will be included and, except where otherwise stated, one Bursary of £150 will be offered in each:

DOMESTIC ELECTRICAL APPLIANCES
ELECTRIC LIGHT FITTINGS
DOMESTIC SOLID-FUEL-BURNING APPLIANCES
CARPETS
DRESS TEXTILES (TWO BURSARIES)
FURNISHING TEXTILES
WOMEN'S FASHION WEAR (TWO BIANCA MOSCA AWARDS OF £200 AND £150 RESPECTIVELY)
ACRYLIC SHEET ('PERSPEX')
LAMINATED PLASTICS
FILM, STAGE AND TELEVISION SETTINGS (THREE BURSARIES)
FOOTWEAR
FURNITURE (TWO BURSARIES)
JEWELLERY
PACKAGING
POTTERY
TYPOGRAPHY
WALL-PAPER

In addition to the above Bursaries, the Council of the Society may provide supplementary awards from the Art Congress Studentship Trust Fund and from the Owen Jones Memorial Trust Fund; and subject to certain conditions, successful candidates will also be offered Associate Membership of the Society.

The Sir Frank Warner Memorial Medal will be awarded to the candidate submitting the best design in the Set Test in either the Furnishing Textiles, Dress Textiles, or Carpet sections of the Competition, if of sufficient merit. This Medal may be awarded to a successful candidate in addition to a Bursary.

The last day for the receipt of entry forms is 14th October, 1957.

ROYAL DESIGNERS FOR INDUSTRY

His Royal Highness the President was present at a luncheon of the Faculty of Royal Designers for Industry, held at Kettner's Restaurant, on Friday, 10th May. The luncheon followed a ceremony at the Design Centre at which The Duke of Edinburgh had presented certificates to the manufacturers of the 12 articles chosen by a panel of the Faculty as the 'Designs of the year'. (Further reference is made to this latter event in the General Note section at the back of this *Journal*.) Also present at the luncheon were: Dr. Holland, *ex officio* President of the Faculty; Mr. Milner Gray, Master; Dr. W. J. Worboys, Chairman of the Council of Industrial Design; Lieutenant-General Sir Frederick Browning; Mr. J. B. Orr; and the following members and officials of the Faculty: Mr. Christian Barman; Mr. Reco Capey; Mr. Uffa Fox; Mr. Barnett Freedman; Mr. James Gardner; Mr. Laurent Giles; Professor R. Y. Goodden; Dr. Charles Holden; Mr. Lawrence Irving; Sir William Lyons; Sir James McNeill; Mr. Keith Murray; Mr. Brian O'Rorke; Mr. E. C. Ottaway; Mr. Ernest Race; Mr. A. B. Read; Sir Gordon Russell; Professor R. D. Russell; Mr. Reynolds Stone; Mr. Fred Taylor; Dr. Barnes Wallis; the Secretary, and the Assistant Secretary.

THE SOCIETY'S CHRISTMAS CARD, 1957

The Society's House, by Thos. Malton, 1790

As announced in the last issue of the *Journal*, the subject of the Society's Christmas card for this year, which is reproduced above, is a reproduction of an eighteenth-century hand-coloured engraving of John Street (as it then was), Adelphi, produced by Thomas Malton in 1790. It will be readily appreciated that the Council chose this picture to mark the extension of the Society's headquarters to include the whole of the building as shown on the left-hand side of the drawing.

Particulars of prices and an order form were included in the last issue of the *Journal*, and will be repeated from time to time.

MEETING OF COUNCIL

A meeting of Council was held on Monday, 13th May, 1957. Present: Dr. R. W. Holland (in the Chair); Sir Alfred Bossom; Sir Edward Crowe; Mr. P. A. Le Neve Foster; Sir Ernest Goodale; Mr. Milner Gray; Mr. William Halcrow; The Earl of Halsbury; Mr. A. C. Hartley; Mr. William Johnstone; Sir Harry Lindsay; Mr. F. A. Mercer; Mr. O. P. Milne; Lord Nathan; Mr. A. R. N. Roberts; Mr. E. Munro Runtz; Sir Harold Saunders; Sir Selwyn Selwyn-Clarke; Professor Dudley Stamp; Sir Stephen Tallents; Mr. G. E. Tonge; Dr. Barnes Wallis and Sir Griffith Williams; with Dr. K. W. Luckhurst (Secretary); Mr. G. E. Mercer (Deputy Secretary) and Mr. David Lea (Assistant Secretary).

ELECTIONS

The following candidates were duly elected Fellows of the Society:

Allan, John, Ayr, Ayrshire.
Brown, Robert, Belfast, Northern Ireland.
Burwell, William Ernst, Hillingdon, Middlesex.
Cave, Julius Jack, South Ruislip, Middlesex.
Cochran, Miss Constance Marie, D.A., Glasgow.
Comfort, Professor Charles Fraser, Toronto, Ontario, Canada.
Constantinou, Antis Michael, Larnaca, Cyprus.
Crowdis, Donald Kennedy, B.A., B.Sc., Halifax, Nova Scotia, Canada.
Davies, Harold Percy Howard, Beckenham, Kent.
David, John Jarrett, M.Sc., A.C.G.I., D.I.C., London.
Endersby, Kenneth, Leeds, Yorks.
Greene, Brian David, South Croydon, Surrey.
Harris-Marshall, Leonard, Sunbury-on-Thames, Middlesex.
Haworth, Peter, D.F.C., A.R.C.A., Toronto, Ontario, Canada.
Jaafar, Mohamed Ali, Kelantan, Malaya.
Kahn, Irving Jack, London.
Latham, Commander Guy Deverell, R.N. (ret.), Upham, Hants.
McGrath, Sean Anthony, London.
Massey, Bernard Stanford, B.Sc., Ph.D., Redhill, Surrey.
Milton, Denis Claude, Toronto, Ontario, Canada.
Morley, Maurice Arnold, Mapperley, Nottingham.
Muggeridge, John Franklin Charles, London.
Porter, Desmond William, Frimley, Surrey.
Richards, Oliver Haydn, Mansfield, Notts.
Rostron, David Jodrell, M.A., Alnwick, Northumberland.
Sander, Joseph Edward, London.
Sansome, Professor Frederick Whalley, B.Sc., Ph.D., F.L.S., F.R.S.E., Ibadan, Nigeria.
Schumann, Lawrence Rill, Boston, Massachusetts, U.S.A.
Seager, Sir George Leighton, Bart., C.B.E., D.L., J.P., St. Mellons, Mon.
Short, Samuel Jocelyn Augustine, Freetown, Sierra Leone.
Smith, Arthur Llewellyn, M.B.E., M.A., F.R.I.B.A., London.
Speight, Harold, Lightcliffe, Yorks.
Taylor, Walter Andrews, M.Arch., Washington, D.C., U.S.A.

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Milton, Denis Claude, Toronto, Ontario, Canada.
Morley, Maurice Arnold, Mapperley, Nottingham.
Muggeridge, John Franklin Charles, London.
Porter, Desmond William, Frimley, Surrey.
Richards, Oliver Haydn, Mansfield, Notts.
Rostron, David Jodrell, M.A., Alnwick, Northumberland.
Sander, Joseph Edward, London.
Sansome, Professor Frederick Whalley, B.Sc., Ph.D., F.L.S., F.R.S.E., Ibadan, Nigeria.
Schumann, Lawrence Rill, Boston, Massachusetts, U.S.A.
Seager, Sir George Leighton, Bart., C.B.E., D.L., J.P., St. Mellons, Mon.
Short, Samuel Jocelyn Augustine, Freetown, Sierra Leone.
Smith, Arthur Llewellyn, M.B.E., M.A., F.R.I.B.A., London.
Speight, Harold, Lightcliffe, Yorks.
Taylor, Walter Andrews, M.Arch., Washington, D.C., U.S.A.

Turner, Joshua Austin, London.
Wernham, Frederick David, London.
Wild, George Edward, Chippenham, Wilts.
Williams, Huw, A.T.D., Newcastle, Staffs.
Wilson, John Leslie, Southampton, Hants.
Wood, Frederick, Blackpool, Lancs.

The following was elected an Associate Member as winner of an Industrial Art Bursary in 1956:

Kennedy, Tyl O'Brien, Heyford, Oxford.

The following were admitted as Institutions in Union under Bye-Law 66:

The Incorporated Association of Architects and Surveyors, London.
The Cooper Union for the Advancement of Science and Art, New York, U.S.A.

ALBERT MEDAL

Further consideration was given to the award of the Albert Medal for 1957 and a name was selected for submission to His Royal Highness the President.

CHAIRMAN OF COUNCIL, 1957–58

Sir Alfred Bossom, Bart., M.P., was nominated to serve as Chairman of Council for the year 1957-58.

BALLOTING LIST

The balloting list for the new Council was prepared for the Annual General Meeting.

EXAMINATIONS

It was reported that 51,518 entries had been received for the Whitsun series of examinations, which represented an increase of 3,397 on the number for the corresponding examinations last year.

NATIONAL ADVISORY COMMITTEE ON ART EXAMINATIONS

A committee was appointed to consider the Report of the National Advisory Committee on Art Examinations upon which the Minister of Education had invited the Society to comment.

NATIONAL BOOK LEAGUE

In response to an invitation from the National Book League, the Master for the time being of the Faculty of Royal Designers for Industry was nominated to serve on the National Council of that body.

OTHER BUSINESS

A quantity of financial and other business was transacted.

TRACE ELEMENTS IN PLANT NUTRITION

WITH SPECIAL REFERENCE TO CROPS

The Fernhurst Lecture by

T. WALLACE, C.B.E., M.C., D.Sc., F.R.I.C., V.M.H., F.R.S.,

Professor of Horticultural Chemistry, University of Bristol, and Director, Long Ashton Research Station, delivered to the Society on Wednesday, 6th March, 1957, with Sir William Slater, K.B.E., D.Sc., F.R.I.C., Secretary, Agricultural Research Council, in the Chair

THE CHAIRMAN: Before we proceed to the business of this eighth Fernhurst lecture, I would like to say to you how much we shall all miss our old friend and colleague Sir John Simonsen, who was a member of the Council and who has particularly associated himself with these lectures. It is only within the last year that he has resigned from the last Committee, of which he was chairman, of my Council, and we shall all miss him very much, not only for his wisdom and his knowledge, but also as a charming person and friend.

Professor Wallace, is a very old friend of mine. There can be hardly anyone who is connected either with farming or horticulture or is just a plain gardener who does not know something of Professor Wallace's work. His book on the mineral deficiencies in plants is a best seller. I remember when I first came to the Agricultural Research Council we were in the midst of getting that book published, and there was some hesitation and worry as to whether it would in fact sell well. We quickly found we had made a very serious mistake, and we were soon busy trying to get out a second edition.

His work had enormous value during the War in encouraging the production of crops in areas where it had been said they could not be grown. By correcting the deficiencies he succeeded in making land bear crops where the general opinion was they would not grow at all.

He is the Director of our Research Institute at Long Ashton, and the Head of the Unit of Plant Nutrition, particularly concerned with micro-nutrients. Unfortunately, the time will come soon when he will have to retire. This gives me an opportunity of saying how terribly sorry we all are that that day is approaching, and how much we shall miss his actual guidance of the Institute and the Unit, although we all hope that he will keep himself closely associated with all our activities in the future.

The following lecture, which was illustrated with lantern slides, was then delivered:

THE LECTURE

In analyses made of the ash of plants approximately sixty elements have been identified. Some of these have occurred so consistently as to suggest their

essential nature for plant growth and others in a manner denoting that their presence is likely to be fortuitous. Studies of these elements have led to their classification, in relation to plant growth, into three groups:

(*a*) *essential* elements, regarded as necessary for the growth and reproductive processes of the plants;

(*b*) *beneficial* elements, which may produce beneficial effects on growth, but in the absence of which plants can carry out their growth and reproductive functions satisfactorily;

(*c*) '*other*' elements, which have not been shown to perform any useful function in growth or reproduction and whose presence in the plant may in fact be harmful.

So far 16 elements have been established as essential, namely: carbon, hydrogen and oxygen, and the so-called mineral nutrients, nitrogen, phosphorus, calcium, magnesium, potassium, sulphur, iron, manganese, boron, copper, zinc, molybdenum and chlorine.

Examples of the beneficial elements are sodium, silicon, aluminium and bromine.

In this lecture I shall be discussing problems of the mineral nutrition of plants and especially the part played in this by the so-called trace elements. As a preliminary to this, I should like to refer again to the grouping of the mineral elements found in plants, to show how the trace elements occur in these groups.

Group (*a*): the 13 essential mineral nutrients are divided into two sub-groups:

(i) *Major nutrients*—nitrogen, phosphorus, calcium, magnesium, potassium and sulphur;

(ii) *Minor* or *trace elements* or *micro-nutrients*—iron, manganese, boron, copper, zinc, molybdenum and chlorine.

Chlorine has been placed tentatively in the trace elements group, though its position would seem to be intermediate between the major and minor groups.

The division of essential elements into major and trace elements groups is not based on the relative importance of the elements in the nutrition of plants, but merely reflects the quantities of the elements usually present in plants—major elements occur in plants in relatively large amounts and trace elements in relatively small amounts. Thus, whereas we generally record the contents of major elements in plants on a percentage basis, trace elements are usually expressed as parts per million. The elements are of equal importance for the plant in that the absence of any one of them will result in death.

On this purely quantitative basis *non-essential* trace elements may also occur in groups (*b*) beneficial, and (*c*) 'other' elements, and indeed a number of these trace elements known for their harmful effects on crops and livestock are, in the present stage of knowledge, grouped in (*c*). The present position of the elements in groups (*b*) and (*c*) should not be regarded as final, since further investigations, using more refined methods than are at present available, may

alter their grouping. This relates especially to trace elements; thus molybdenum and chlorine have been shown only recently to be essential and placed in group (*a*).

Elements in all three groups may affect the growth of plants, the 'other' elements, so far as is known, only adversely. The overall picture of the mineral content of plants in relation to their nutrition is referred to as the *mineral status*.

Other points that are of interest in considering problems of trace elements in plants are as follows:

1. Although plants show considerable powers of selective absorption for mineral elements, they have no special mechanism to exclude injurious elements that may occur in soils.

2. Some plants act as accumulators of particular elements, for example *Astragalus* sp. of selenium; many monocotyledons of silicon; the tea plant, hickory and some ferns of aluminium; and many plants that grow well on acid soils of manganese and aluminium. Němec has reported the accumulation of gold by *Equisetum palustri* from some soils in Bohemia, and the presence of metallic mercury in the capsules of *Holosteum umbellatum*.

It should be mentioned also that the needs for trace elements of plants and animals are not coincident, though some of the present discrepancies may be due to lack of knowledge. Thus cobalt and iodine are regarded as essential for animals but have not so far been proved to be so for plants. Again, some plants may accumulate either essential or 'other' trace elements in amounts that are highly toxic to animals, for example, molybdenum and selenium, but not to the plants.

HISTORICAL ASPECTS OF TRACE ELEMENTS RESEARCH

Interest in the role of trace elements in the nutrition of plants was beginning to be shown about the middle of last century, about the time when Liebig was expounding his views on the mineral nutrition of crops, based on ash analysis. Thus Sachs and Knop, in 1860, working independently with water cultures of plants, both included iron as an essential constituent of their nutrient solution. Later work has amply confirmed this early view and it is unnecessary here to give details of the later development regarding this element.

In France, a number of workers used the fungus *Aspergillus niger* in early studies of mineral nutrition problems, and in 1869 Raulin suggested that zinc was probably essential for this organism. In 1897 Bertrand stated that manganese was probably necessary for the functioning of the enzyme laccase, and in 1905 using *Aspergillus*, claimed that manganese was essential for its growth. In 1911, Bertrand and Javillier claimed that both manganese and zinc were necessary for this fungus and in 1914 Mazé showed that both were essential for a higher plant, maize.

In 1910, Agulhon obtained increased growth by supplying boron to a number of crops, including wheat, oats and turnip, and by 1914–15 Mazé regarded boron as an essential element. This view was finally confirmed by Miss Warington at Rothamsted in her work on the broad bean, and the importance of boron

for agricultural crops was later shown by Sommer and Lipman (1926) for cotton, buckwheat, and some other crops, and by Brandenberg (1937) for sugar beet and mangold, and later by other workers for a large range of crops, including swede, cauliflower, lucerne, celery, tobacco, apples and other fruits.

The essential nature and importance of manganese for many crop plants were shown from 1922 onwards, notably by McHargue (1922 to 1928) and Samuel and Piper (1928, 1929). The crops included cereals, particularly oats, sugar beet, peas, sugar cane and various tree fruits, and 'diseases' recognized as resulting from deficiency of the element included 'Grey Speck' of oats, 'Speckled Yellows' of sugar beet, 'Marsh Spot' of peas, 'Pahala Blight' of sugar-cane, and 'Frenching' of fruit trees.

Bortels (1927) demonstrated that copper was essential for *Aspergillus niger*. Diseases of Rosaceous species and of citrus, later shown to be caused by deficiency of copper, had been recognized in Florida as early as 1875, and in 1917 Floyd had reported the beneficial effects of copper on diseased citrus trees. In 1931 Sommer proved that copper was essential for sunflower and flax, and in the same year Lipman and Mackinney showed that flax and barley fail to produce seed in the absence of copper. Since that time the range of crops requiring copper has been greatly extended, including cereals, Sjollema (1933) and many fruit crops, Anderssen (1932) and Oserkowsky and Thomas (1933).

The early work of Bertrand and Javillier on the essential nature of zinc for *Aspergillus niger* was confirmed by Steinberg (1919), who used new purification methods to prepare his nutrient solutions, and later by Bortels (1927).

Working on crop plants, Sommer and Lipman (1926) and Sommer (1928) showed that zinc was essential for sunflower, barley, buckwheat and broad bean, and thus confirmed the early findings of Mazé (1914) for this element. These results were quickly followed by numerous others in connection with diseased conditions of various crops, for example, 'White Tip' of maize, 'Little Leaf' of deciduous fruits, and 'Mottle Leaf' of citrus.

In 1930 Bortels drew attention to the importance of molybdenum in the processes of nitrogen fixation by soil organisms, and in 1937 Steinberg showed that the element was essential for *Aspergillus*. In 1932 Ter Meulen published a paper in *Nature* describing the wide distribution of molybdenum in plants and in 1939 Arnon and Stout showed this element to be essential for the growth of tomato in water culture at the low rate of one part per 100 million. Piper (1940) obtained a similar result with oats and Hoagland (1941) with Myrobalan plum. Since 1941 these results have received ample confirmation for many plants: Anderson and Fricke for pasture plants in Australia, Davis for Brassica crops in New Zealand, and Hewitt for many crop plants and Nicholas for micro-organisms at Long Ashton. Deficiencies of this element have also been shown to be of importance in crops in many countries, notably in Australia, and including Great Britain.

The evidence for the essential nature of chlorine for higher plants is very recent, though the element, as the chloride ion, was used in the original nutrient solutions of Sachs, and as early as 1862 Nobbe had claimed beneficial effects on plant

growth from its use. Since that time many investigators have endeavoured to determine whether chlorine is essential for the growth of higher plants, Pfeffer (1900), Mazé (1919), Lipman (1938), but the final proof of its essential nature was obtained as recently as 1955 by Broyer, Carlton, Johnson and Stout for tomato. The great difficulty in working with this element has been its ubiquitous presence in soils, water, chemicals and the atmosphere. The experiments of these latter workers also showed that bromine could reduce the requirement of tomato for chlorine.

In addition to the above trace elements, claims for essentiality for micro-organisms have also been made in respect of vanadium, tungsten and gallium, but so far there is no conclusive evidence to show that they are concerned directly with the growth of higher plants.

THE FUNCTIONS OF TRACE ELEMENTS IN PLANT NUTRITION AND THEIR EFFECTS ON CROPS

Knowledge of the special functions of the various trace elements in the metabolic processes of higher plants and micro-organisms is at present very limited and biochemical studies relating to functions would seem to offer a most important field for investigation in the immediate future. It is clear, however, that their main functions are likely to be as catalysts in vital enzyme systems and especially in systems concerned with oxidation/reduction reactions. In these latter reactions trace elements with multiple valencies are likely to play important roles, as has already been shown for iron in Cytochrome respiration systems, for copper in oxidase systems involving polyphenol constituents, and for molybdenum in the nitrate reductase system.

Points that may be made for the various elements are as follows:

Iron and manganese are concerned in oxidation/reduction systems, sometimes probably in antagonistic roles, and with problems of chlorophyll formation.

For boron many functions have been suggested. The subject has recently been reviewed by Gauch and Duggar, who have suggested the main function of boron as 'a specific role in the translocation of sugars'. This view is complicated by the fact that plants suffering from boron deficiency may show severe phloem necrosis. Other suggested roles for boron relate to pollen germination, tissue differentiation, metabolism of pectic substances, regulating supplies of soluble calcium, and water relations in tissues.

Copper may have as its most important function its role in oxidase systems of polyphenol constituents, and it is obviously important in meristems.

Zinc also has been suggested as concerned with oxidation/reduction reactions and, according to Reed and Dufrenoy, with reactions regulating the oxidation of phenolic compounds by catechol oxidase in cell vacuoles. Skoog has also associated deficiency of zinc with the excessive destruction of auxin within the plant.

Molybdenum has been shown by Nicholas and Nason to be an essential metal constituent of nitrate reductase, both in higher plants and in micro-organisms.

It also appears to be concerned in nitrogen fixation processes by nodule organisms and to play some role in ascorbic acid systems.

Warburg and Luttgens and Arnon and Whatley have shown that the chloride ion can speed up photosynthesis *in vitro*, though it was not apparently essential to the process. Warburg and Luttgens suggested that the chloride ion may function as the essential co-enzyme for photo-chemical reactions in photo-synthesis.

Although so little is known of the special functions of the trace elements, much information is available regarding the pathological effects that result in plants from deficiencies and excesses of them. In view of their scientific interest and their importance in crop production, some of the main effects are summarized below and will be illustrated in the lecture.

Deficiencies

Iron: The main symptom of this deficiency is always severe chlorosis of the leaves, and the young leaves are always most severely affected. The leaves may

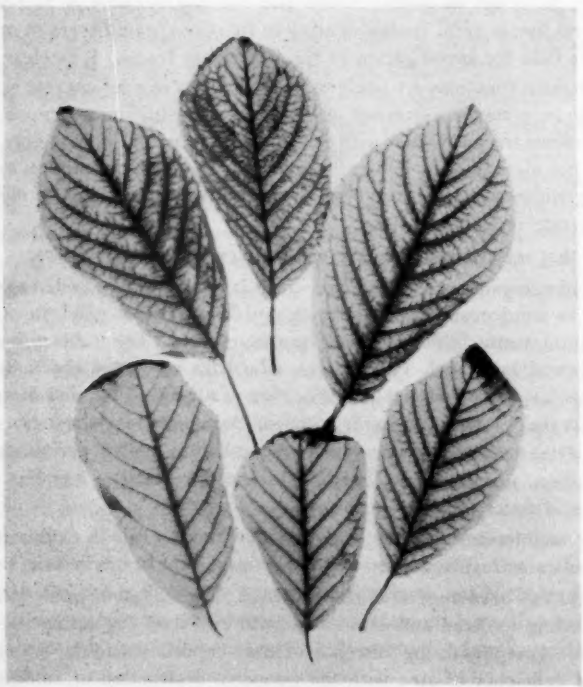

FIGURE 1. *Iron deficiency, Sweet Cherry leaves. Leaves show typical chlorotic pattern of iron deficiency. Note the veins, including the sub-laterals, remain green in the early stages*

be almost completely bleached or the chlorosis may occur as a mottled pattern in which the veins remain green. Scorching of leaf margins and tips may follow on the chlorotic condition, and young shoots bearing affected leaves often die back from the tips. Fruits may be highly flushed. On some broad-leaved crops, for example, Brassicas, the chlorosis develops as a 'marbling' pattern, and in monocotyledons the pattern comprises alternating stripes, for instance cereal crops. Many tree crops, especially Rosaceous species, and plants that occur naturally on acid soils, are highly susceptible to the deficiency, but many farm crops are resistant.

FIGURE 2. *Manganese deficiency, runner bean, broad bean and pea seeds. The cotyledons of beans and peas develop brown lesions in their centres. In peas the condition is known as 'Marsh Spot'*

Manganese: Symptoms of manganese deficiency vary for the different plants. Chlorosis of the leaves is one of the most common effects to be observed. The chlorotic pattern produced is often quite distinct from that resulting from iron deficiency, the chlorosis developing as V-shaped areas from the leaf margins

towards the mid-ribs, and leaving only the mid-rib and areas along the sub-main veins green. Often also the young foliage may remain green when other leaves of the plants are affected, another point of difference from iron.

Special semi-chlorotic patterns are shown by cereal crops: irregular lesions on oats, known as 'Grey Speck' disease; intermittent chlorotic streaking in wheat and rye, and a general yellowing with some brown spotting on barley. In some plants the chlorosis first develops as a marbling pattern, the affected areas later becoming necrotic, as in 'Speckled Yellows' of beets. Brassica crops also develop 'marbling' patterns in the early stages. In potatoes and tomatoes the leaves develop brown necrotic spotting patterns, often along the areas of the veins, and there may be some chlorosis. Legumes develop characteristic lesions in the seeds, known in peas as 'Marsh Spot'.

Boron: Boron deficiency is characterized by a large number of so-called 'diseases' which render crops either worthless or of very low value. The various conditions have been given descriptive names, such as 'Heart Rot' of sugar beet and mangolds, 'Canker' of table beets, 'Brown Heart' or 'Raan' of swedes and turnips, 'Hollow Stem' of cauliflower, 'Cracked Stem' of celery, alfalfa 'Yellows', 'Drought Spot', 'Cork', 'Corky Core' or 'Corky Pit' of apples, 'Hard Fruit' of citrus and 'Top Sickness' of tobacco. All these diseases provide evidence of the

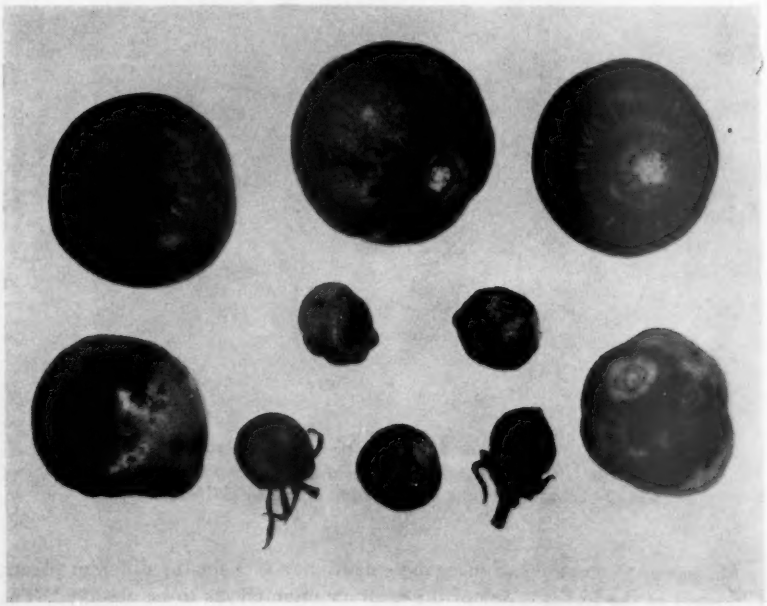

FIGURE 3. *Boron deficiency, tomato fruits. Skin shows cracked, pitted and corky areas; the fruits are misshapen and may fail to swell*

failure of meristems to differentiate properly, for example shoot tips, pith and epidermis of stems. The deficient plants often bear highly tinted leaves, which may also show marginal browning, and growths, including leaves, shoots, flowers and fruits, may be severely deformed.

FIGURE 4. *Copper deficiency, young pear tree. Terminal leaves become distorted and are shed; the defoliating shoots die back from the tips*

Copper: Deficiency of copper may result in some chlorosis of leaves, but the main effects produced are the dying back of shoots and leaf tips, with in some plants the development of deformed shoots and in some species, for example 'Prunus', severe gumming. Leaf die-back is often followed by defoliation in a basipetal direction, and shoot die-back by the development of adventitious shoots at lower levels, for instance excessive tillering in cereals and 'suckering' in trees. In instances of severe deficiency, fruiting and grain formation may be totally suppressed. The special features of this deficiency have given rise to the names 'Summer die-back' of apples, 'Exanthema' of citrus, and 'Wither Tip' disease of cereals.

Zinc: The main effects of zinc deficiency are chlorosis, the restricted development of leaves, which remain small and narrow, and the progressive shortening of the internodes of shoots, which in extreme instances results in the formation of clusters of leaves resembling rosettes. In some plants the leaves may also develop purple tints, as in tomato and wheat. Here again, the characteristic effects produced by the deficiency have given rise to descriptive names, such as 'White Bud' of maize, 'Mottle Leaf' of citrus, 'Rosette' and 'Little Leaf' of fruit trees, and 'Sickle Leaf' of cacao.

FIGURE 5. *Zinc deficiency, apple tree. Leaves are small and narrow and internodes short, giving rise to the conditions known as 'Little Leaf' and 'Rosette'. Branch in left centre, bearing larger leaves, has been injected with zinc sulphate*

Molybdenum: In tomato and Brassicas deficiency of molybdenum may result in chlorotic mottling of the leaves where nitrates are given as the source of nitrogen to the plants. In these plants there may be also considerable incurling of the leaf margins. Most plants exhibit marked leaf effects, showing in the early stages areas of thin lamina tissue which dry out and become necrotic. In cauliflower lamina development may eventually become suppressed, giving rise to the condition known as 'Whiptail'. Curd formation is also suppressed and the growing point may die. In the tomato the older leaves are the most severely affected, and the shoots may continue growth. In citrus the leaves become highly tinted, gum spots are formed on the under surfaces and the

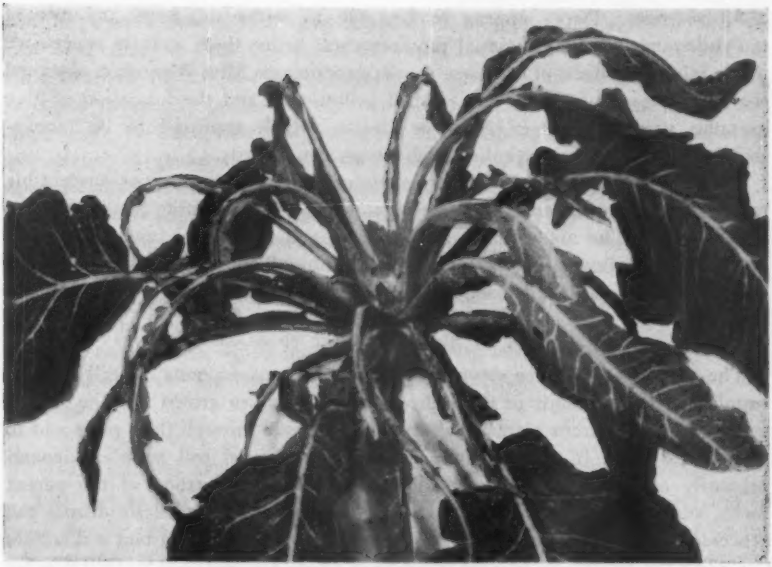

FIGURE 6. *Molybdenum deficiency, cauliflower. Oldest leaves relatively large. Later-formed leaves are progressively smaller and laminae fail to develop (Whiptail condition). The growing point eventually dies and there is no curd formation*

shoots die back. In leguminous plants the deficiency may show as a deficiency of nitrogen, since the nodule organisms fail to fix enough nitrogen for the plant's requirements. When sufficient nitrogen is supplied to legumes and molybdenum is deficient, the plants then show symptoms similar to other plants, that is, the development of necrotic leaf areas followed by total collapse and death.

Chlorine: So far observations have been reported only for tomato. For this plant the symptoms comprised wilting of the leaf tips, followed by chlorosis, bronzing and necrosis of leaflets in a basipetal direction.

Excesses

Iron: Excess of iron may produce brown lesions on the leaves and induce deficiencies of manganese and phosphorus.

Manganese: The two main effects of manganese excess are to induce a deficiency of iron and to produce brown blotchy lesions in leaves, petioles and stems.

Boron: Excess boron in plants tends to accumulate in the older leaves, which develop marginal and interveinal necrosis. Severe injury may result from quite small excesses.

Copper and Zinc: Excesses of these two elements tend to induce a deficiency of iron, the condition being evidenced by severe chlorosis and necrosis of the leaves.

Molybdenum: Plants appear to be able to withstand large amounts of molybdenum above their actual requirements; hence there is little experience of the injurious effects of excesses. In pot experiments Miss Warington observed the development of golden and reddish-yellow tints and the formation of blue granular accumulations in *Solanum* species, which appeared to be tannin-molybdenum and anthocyanin-molybdenum compounds.

Chlorine: Excess effects of chlorine are often apparent on crops susceptible to chloride injury where heavy dressings of chloride-containing fertilizers have been applied. The main effects are marginal and interveinal browning of the leaves, often followed by premature defoliation. The scorch effects may be mistaken for potassium deficiency.

THE OCCURRENCE OF TRACE ELEMENT PROBLEMS IN CROPS

The occurrence of trace element problems in crops depends basically on the supplies of the elements in the soils on which they are grown and the special powers of the different plants to absorb the elements through their roots and to accumulate them in their various organs. The natural soil supplies depend primarily on the mineral composition and mode of formation of the parent rocks, and the subsequent changes brought about in the minerals during the processes of soil formation. The special effects of the more important soil factors that affect the availability of trace elements to plants are discussed in the following section.

The special properties of the individual crops are of considerable importance, particularly their special needs for the different elements, their different powers of extracting the elements from the soil, and the large differences shown in withstanding toxic levels of elements and in the specialist accumulation of particular elements.

These points relating to soils and crops must be borne strongly in mind in considering both the occurrence and distribution of trace element problems in world agriculture. Thus, in some areas, soil conditions may be the pre-eminent feature determining the problems, and in others the special nature of the crops may be of prime importance; usually, however, where outstanding problems occur, both soils and crops will play important roles.

It is evident from the literature that important trace element problems in crops are of world-wide occurrence. They occur in both hemispheres, in areas extending from the regions of low temperatures to the equator, and include a very wide range of crops. At present, however, it is not possible either to assess accurately their importance or to map their distribution in different regions of the globe, since investigations relating to them have been carried out in varying intensity in different countries. Hence, any world map based on current data would largely reflect the activities of research workers in different countries, rather than provide a true picture of the importance of trace elements in world crop production.

So far as I am aware, the only serious attempt that has been made to map the distribution of trace element problems for a whole country is that of Beeson

for the United States. His maps relate both to crops and livestock and are compiled from the data reported in the various scientific and technical agricultural journals of that country. Although these maps are biased by workers' interests in special problems, they do bring out the wide distribution and importance of trace elements in United States agriculture, and illustrate the importance of geology, climatic factors, soil types, farming systems, and the special characters of crops in affecting the occurrence of the problems.

In Great Britain much local information exists regarding the occurrence, nature and importance of various trace element problems, but so far we have not been able to obtain suitable data for the making of detailed maps, though generalized maps could possibly be made for certain areas where special problems are of common occurrence.

Other countries in which much work has been carried out on trace element problems include Australia, New Zealand, Holland, Denmark, Finland and Canada.

SOIL FACTORS AFFECTING THE SUPPLY OF TRACE ELEMENTS TO PLANTS

The soil factors of outstanding importance in affecting the availability of trace elements to plants are: soil reaction (pH); organic matter, together with the soil organisms; drainage conditions, including rate of percolation which controls leaching effects and water logging, and aeration which may be regarded as complementary to drainage conditions.

Soil reaction (pH)

Truog (1948) has summarized in a diagram (Figure 7) the effects of pH over the range pH 4.0 to 10.0 on the availability of five of the seven essential trace elements (the two exceptions are molybdenum and chlorine). It is shown that at low pH values, all the five trace elements figured are readily available to plants, and that their availability decreases steadily at the high diagram pH values, with the exception of boron which shows a second rise above pH 8.5. Of the other two elements, molybdenum shows a steady increase in availability with rise in pH, in contrast to the five mentioned above. Differences in pH would not be expected to produce significant changes in the availability of the chloride ion, which is very soluble and moves freely in soils. These effects produced by pH on the availability of trace elements may alter supplies of some of them over the whole range from deficiency to toxicity levels.

Manganese and aluminium are of especial interest in relation to pH effects, as these elements have been shown to reach toxic concentrations in many acid soils and to be important causes of crop failures in such soils.

Organic matter and soil organisms

These two factors together produce large effects on the availability of iron, manganese, copper and zinc. Of these, the availability of iron appears to be increased by organic matter, whereas the others are rendered less available. Quastel has shown that soil organisms may largely control the availability of

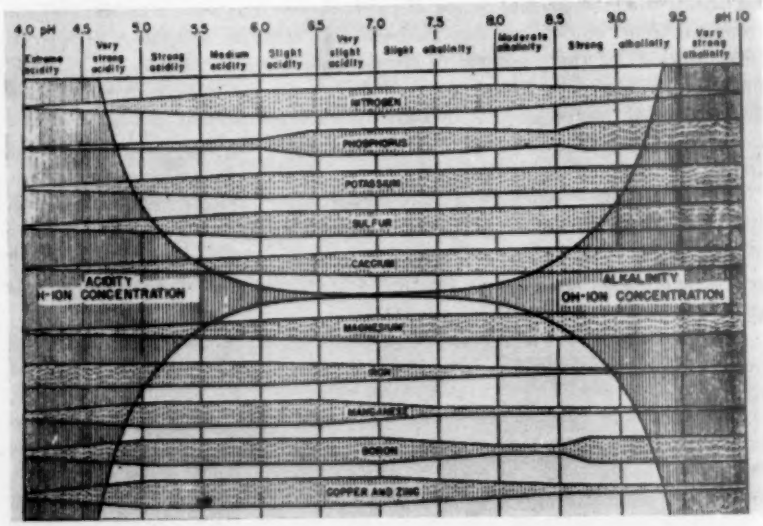

FIGURE 7. *pH and availability of mineral nutrients. Note availability of trace elements iron, manganese, copper and zinc decreases progressively with rise in pH (increase in alkalinity). Boron shows decreasing availability from pH 7.0 to 8.5 after availability increases. (Diagram of E. Truog)*

manganese over the range pH 6·0 to 7·8. The effects of these factors on molybdenum and chlorine are as yet undetermined.

Drainage conditions

On freely-drained soils leaching may result in the serious depletion of all trace elements and losses are likely to be especially large for boron and chlorine, and where soils are strongly acid for manganese also. On the other hand, in waterlogged soils, leaching effects are small and under the anaerobic conditions that prevail the reduced forms of manganese and iron are highly soluble. Nevertheless, absorption by many plants may be relatively low because of the lack of oxygen for their roots and the toxic effects of carbon dioxide.

Aeration

Since water content and oxygen supplies in soils are related, their effects on the availability of the trace elements show some corresponding relationships. Thus, waterlogging results in poor aeration and the net effect, which is the resultant of the high water content and the accompanying low oxygen and high carbon-dioxide concentrations, will depend largely on the needs of the plant root systems for oxygen. Where water content is low and aeration good, iron and manganese will tend to be present as the more highly oxidized forms and to be of lower availability.

THE DIAGNOSIS OF TRACE ELEMENTS STATUS IN PLANTS

The methods used for the diagnosis of the status of trace elements in plants are in general those employed for the major elements. These are: (*a*) visual diagnosis; (*b*) the application of foliage sprays and stem injections; (*c*) plant analyses—the analysis of special plant organs, usually leaf laminae, petioles or stems; (*d*) soil analysis, using both chemical and biological methods. Of these methods, (*a*), (*b*) and (*c*) are of general application, though results for iron under (*c*) may be misleading due to contamination, and in cases of induced deficiencies caused by heavy metal toxicities; moreover, quick chemical tissue tests are not generally applicable for deficiency levels of trace elements, because of the limitations of the colorimetric methods. Under (*d*) chemical methods are not always useful, but can be used effectively for manganese, boron and chlorine. The *Aspergillus niger* technique is useful for manganese, copper, zinc and molybdenum, and according to Gerretzen can also be used for boron. So far attempts to use this method for iron at Long Ashton have been unsuccessful as no soil tested has proved to be deficient for the organism.

As for the major elements, the best assessments are made by using combinations of selected methods for the individual elements.

THE CORRECTION OF TRACE-ELEMENTS DEFICIENCIES AND EXCESSES IN PLANTS

Deficiencies and excesses of trace elements in plants often result from the special soil conditions, such as pH level, previously discussed, and from interactions with other mineral elements in the soil, both of the major and trace categories. Where such factors operate to cause deficiencies, methods of correction, other than the application of the deficient element, are generally needed, as otherwise the effects may be negligible or the amounts that need to be added both wasteful and uneconomic. The following notes summarize the main points:

Deficiencies

Iron: Deficiency is nearly always induced, generally by high pH, when the methods used are foliage sprays and stem injections; lowering the pH by sulphur dressings to the soil and grassing down of tree crops may sometimes be used. The most effective materials for use as sprays and also for soil treatment (on acid soils) are iron chelates. Suitable concentrations for chelate sprays are of the order of 0·1 per cent.

Iron deficiency may also be induced by toxic concentrations of heavy metals in the soil. In such circumstances sprays may produce some benefit, but often the only way to obtain even moderate results is to grow crops that tolerate the conditions.

Manganese: For this element high pH with high organic matter and indifferent drainage conditions are common causes of deficiency. As for iron, foliage sprays, injections, and the use of acidifying materials as soil dressings are the most effective curative methods. Soil dressings of manganese salts usually give meagre results. Excessive dressings of acidifying materials may mobilize manganese to toxic levels. For cereals and other farm crops a spray containing five to

ten lb. manganese sulphate in 100 gallons water per acre is generally suitable. For tree crops three lb. manganese sulphate, plus spreader, per 100 gallons of water is used, and if damage is feared 1½ lb. of hydrated lime may be added to the spray. The sprays, as for all trace elements, are best applied to young foliage, though to control 'Marsh Spot' in peas the spray is most effective when applied at the flowering stage.

Boron: Boron deficiency, unlike that of iron and manganese, usually results from a lack of the element in the soil, though here again deficiency may be induced by liming preceding the sowing of a susceptible crop. Since boron compounds are not readily fixed by soils, soil dressings are effective and are preferred to foliage sprays and stem injections, as these may cause serious damage besides being less convenient to apply. Suitable soil dressings for most crops to remedy deficiency conditions are twenty to forty lb. borax per acre. For foliage sprays a suitable strength is of the order of two lb. borax per 100 gallons. It should be noted that the margin between deficiency and excess of boron is narrow, and routine dressings of boron should not be given unless deficiency conditions exist and susceptible crops are grown.

Copper: Copper-containing fertilizers can generally be used successfully to control this deficiency, but the rates needed for different soils vary widely because of fixation effects. Thus on sandy soils in Australia five to seven lb. copper sulphate is effective for cereals, whereas in Denmark, Holland and the United States common rates are of the order of fifty lb. per acre, and may be even higher for some peaty soils. Finely-ground copper ores—oxides and sulphides—may also give good results as soil dressings. For foliage sprays, copper sulphate is generally used at a rate of 0·5 to 1·0 lb. per 100 gallons. As the sprays may be damaging, hydrated lime at half the above rates may be incorporated as a preventive measure.

Zinc: The position with this element is similar to that of copper in that soil fixation effects vary widely and thus on some soils very low rates of zinc sulphate—three to seven lb. per acre—are effective, whilst on others, especially where pH or organic matter contents are high, very heavy dressings may be needed and may even be uneconomic, when foliage and so-called 'dormant' sprays (for deciduous trees) must be used. For foliage sprays one lb. per 100 gallons is usual and for dormant sprays, applied to the trunks and branches of trees, rates ranging from 25 to forty lb. per 100 gallons are suitable.

Molybdenum: Two methods may be used to correct this deficiency, the application of lime dressings and of chemicals containing molybdenum, for example sodium and ammonium molybdates. The lime dressings act primarily by raising the pH and rendering the soil molybdenum more available. The rates of molybdate materials needed are very low—three oz. per acre may be sufficient in some instances, though it is more usual to apply one to two lb. per acre of the salts incorporated in a fertilizer dressing.

These rates used in 100 gallons of water are also suitable for foliage sprays. For some crops, for instance cauliflower, the deficiency has been controlled by

FIGURE 8. *Seed reserves and trace element deficiency, broad bean. Broad bean plants in sand culture lacking copper.* Left: *Plant grown from normal seed.* Right: *Plant grown from seed obtained from a copper-deficient plant*

treating the seed beds used for raising the seedling plants with a solution of sodium molybdate at one lb. per five gallons for ten square yards.

Chlorine: This deficiency is readily controlled by the use of chloride-containing fertilizers, as ordinarily applied to farm crops. The main fertilizers will be muriate of potash, Kainit and agricultural salt.

Excesses

Excesses of most trace elements—molybdenum and chlorine are exceptions—can generally be substantially reduced by liming, and this method is especially useful in practice for manganese and aluminium, which are common causes of crop failures in acid soils, but which do not normally occur in toxic amounts in alkaline soils.

Boron excess is generally best treated by leaching treatment, for example

by ensuring free drainage conditions and applying water if necessary. This would also be most effective against an excess of chloride. For molybdenum excess, acidifying the soil would tend to reduce the molybdenum availability, but often would not be a practical method. Usually it would be necessary to adapt the farming system to the special conditions, as has been done in the 'teart areas', where to-day the deleterious effects of high molybdenum on live-stock are overcome by the feeding of copper supplements to the animals as a preventive measure.

CONCLUSION

In concluding this lecture it will be appropriate to refer to the present position of trace elements in relation to agricultural practice and to point to problems for research in the immediate future. As regards practice, great strides have been made in recognizing trace element problems and in devising treatments to control injurious effects on the yield and quality of crops. There is, however, a widely expressed desire for routine preventive treatments, which perhaps is most often shown by the wish to incorporate so-called 'shot gun' mixtures of the known essential trace elements into fertilizers. I hope that this lecture has shown the undesirability and wastefulness of such a procedure, and the need to adopt methods which treat only deficiencies and excesses after diagnosis. The present position, however, does call for further work, perhaps best undertaken by advisory officers, on local problems of the distribution of trace elements (including the making of maps) in relation to soil types, farming systems and specialist cropping. It also calls for research on problems of multiple deficiencies and excesses of trace elements supplies to fertilizer and liming practices.

On the research side there are several problems calling for immediate research, and among these I should give high priorities to the following: the functions of trace elements in plant growth, particularly their roles in enzyme systems; the effects of trace elements on yields and quality of crops; the examination of further elements to establish, or otherwise, their essentiality for plant growth.

As a matter for co-operative research on a national or international scale, the distribution of trace element deficiencies and excesses and an assessment of their importance in crop production should be undertaken.

For the first three of these, highly specialized scientific techniques will be needed and progress may be slow, but their ultimate effects on agriculture and the advancement of scientific knowledge are likely to be far-reaching.

The co-operative research suggested should eventually provide basic data, both for the extension of crop production and the raising of yields and quality of produce in many countries of the world.

DISCUSSION

DR. E. HOLMES: Some twenty years ago I happened to be working in the Jordan Valley and had occasion to work on bananas which, from the appearance of the fruit and so on, seemed pretty obviously to be suffering from potash deficiency. We put in the soil as much as a ton of potassium sulphate per acre and got no response whatever in the trees or fruit, but quite dilute sprays of potash salts on the foliage gave the effect desired. Does exactly the same sort of thing happen to the minor

elements that Professor Wallace has been talking about? Does he take the same measures in the diagnosis of those deficiencies?

THE LECTURER: Yes, I think I have tried to bring out in this paper that in many of these cases of deficiencies it is not actually the supplies of the materials in the soil but the conditions such as pH, drainage and so forth that are at fault. In the problem you cite you would probably have got the results you needed far better if you had just sprayed on potash with a hose rather than by soil dressings. Potash, of course, is not a trace element but the problems are similar. We have found in dealing with fruit trees in this country that we get the same sort of problem as with bananas. One may have to put on soil dressings of potash for three or four years before a reaction is obtained. I think we have one member of this audience who experienced this many years ago, and I think that he did not believe in my advice for the first three years, but he did in the fourth.

SIR WILLIAM OGG (A Member of Council of the Society): I would just like to congratulate Professor Wallace on his admirable lecture, and also to say how much he and his station have contributed to the knowledge on the subject of trace elements. Giving an historical review of this subject he was very modest about Long Ashton's contributions, but they are very great.

Professor Wallace has touched on the practical problems of diagnosis and treatment. Farmers who suspect a deficiency may be tempted to apply a grape-shot dose of trace elements in sprays or in fertiliser mixtures in the hope of one hitting the mark. This would be very dangerous however, for, as Professor Wallace has pointed out, too much may do more harm than too little. It would be a great advantage to know the areas where deficiencies are particularly liable to occur. We now have soil maps of considerable areas in this country and it would be extremely useful to have some idea of the trace element status of the various soil types. The farmers in areas where deficiencies are most likely to occur could then be advised to be on the look out for them. If they suspect a deficiency, they ought to get their diagnosis confirmed by the National Agricultural Advisory Service before applying remedial measures.

I would like again to thank my old friend Professor Wallace for the delightful and interesting way he has put this subject before us.

MR. H. J. PAGE, C.M.G., O.B.E.: I entirely agree with Professor Wallace that the incorporation of so-called grape-shot, or shot-gun, as standard practice in fertilizer mixtures is fraught with great dangers, but on the other hand it seems to me that a judicious use of properly composed mixtures may have its value for *diagnostic* purposes. I have always felt that maybe for every case of proved and visible trace-element deficiency there may be a large number of cases not of crop failure, but of crop limitation where a trace-element deficiency is just beginning to occur—it is incipient, at a marginal value—and before the ordinary grower, at any rate, will notice anything wrong with the leaves. If you are going to have to try to diagnose possible crop limitation of that kind by eliminating the possible trace-elements in turn, it is very laborious. If, on the other hand, you could try a blunderbuss mixture and found that it had no effect on your yield, then you could be pretty sure that you are not short of *any* of the trace-elements, in that mixture. If you do get a favourable effect then you can start trying them separately. Simply as a quick sorting method to see whether there is any indication of some trace-element deficiency or not, purely as an experimental method, it seems to me that there may be still some possibilities in such mixtures.

THE LECTURER: I think I can agree fifty per cent with Mr. Page, but for the other fifty per cent I would not go with him. You may very well put on your blunderbuss mixture and not get a result, and yet there might be trace-element deficiency. Such

a result might arise from antagonisms between the trace-elements as referred to in the lecture.

MR. PAGE: I am not only thinking of fertilizer; I was thinking of putting on with a spray.

THE LECTURER: When putting on as a spray there still remains the question of damage from applying too much, and effects of inter-actions of the elements, and so forth. For example, if you use a copper spray, you only want very little copper on the leaf or damage occurs, and if you add some other element with it you would probably make the spray more damaging. In some circumstances I think you would probably have to go the whole hog and try all the elements separately, but in most cases you would not need to try the lot because you would have some indication beforehand. For instance, if the soil is acid it probably is not iron or manganese; again, if the soil is highly alkaline, it is probably not molybdenum; so that you do not need to go through the whole list of trace-elements and can cut down the tests a good deal.

MR. J. W. G. MACINTYRE: I should like Professor Wallace to put forward a few deductions he might expect in the normal agricultural course where the deficiencies in the trace-elements are sub-clinical. It is of considerable interest to me as a practical fertilizer manufacturer to find out if, even when yields are observed to be high by national standards, we can possibly increase them still further by correcting a deficiency which is not easily diagnosed. Professor Wallace made the point that treatment should only be made after diagnosis, but I imagine a case where there is a potential loss of yield where diagnosis of the actual deficiency would be terribly difficult. There is a crop which looks perfectly normal, but perhaps you could get, shall we say, another ton per acre, due to so many parts per million of such and such a fertilizer nutrient.

I was interested in the lecturer's remarks about the necessity to do further research into the incidence of these deficiencies, and I wonder if it would be possible to use, rather than a blunderbuss treatment, indicator plants? For example, in the area where I operate we grow some 15,000 acres of sugar beet, and it would be quite easy to persuade a large number of farmers to incorporate the odd row or two of some other plant which would show up more easily the deficiencies to which the sugar-beet crop might be subject, if there are plants that could be used as indicator plants in that way.

THE LECTURER: We have, of course, always used indicator plants, but in any case the sugar-beet plant is a pretty good indicator plant itself. With regard to increasing yields under sub-optimal conditions, I am afraid there is no other way of examining such cases except by finding out first qualitatively what is the nature of the trouble, and then carrying out exact quantative experiments which may have to be pretty comprehensive and detailed. You have to examine both the qualitative and the quantitative aspects before you can really solve a problem of that type.

A vote of thanks to the Lecturer was carried with acclamation.

THE LECTURER: I would like to take this opportunity of thanking Sir William Slater and the Agricultural Research Council for the way in which they have so generously helped us to carry out our work at Long Ashton, and I should also like it to be known that much of the work, or all the work, that is being turned out there now is due to my colleagues. They came as young men to me, and they really are now digging deeply into these problems, particularly on the bio-chemical side, and it is on that side I think that we can hope to see the big advances in the future.

A vote of thanks to the Chairman was carried with acclamation, and the meeting then ended.

HOUSING AND BUILDING IN THE COMMONWEALTH

The Henry Morley Lecture by

G. A. ATKINSON, B.A.(Arch.), A.R.I.B.A.,

Colonial Liaison Officer, Building Research Station, D.S.I.R., and Housing Adviser to the Colonial Office, read to the Commonwealth Section of the Society, on Tuesday, 12th February, 1957, with Sir Hilton Poynton, K.C.M.G., Joint Deputy Under-Secretary of State, Colonial Office, in the Chair

THE CHAIRMAN: Mr. Atkinson has been the Colonial Liaison Officer at the Building Research Station of the Department of Scientific and Industrial Research, in liaison with the Colonial Office, for getting on for nine years now and has been for some four years also the Housing Adviser to the Colonial Office. During that time he has travelled very extensively, not only in the Colonial territories, but in other tropical and sub-tropical areas, disseminating knowledge and adding to the very considerable body of knowledge which he already possesses. That, I think, is the secret of this business of technical advice and technical assistance. What we like very much about Mr. Atkinson is that he is one of those rare experts who manages somehow to keep his head not in, but above, the clouds and his feet at the same time firmly on the ground. We have always found that the advice which he gives us is not only imaginative and progressive but thoroughly sound and practical. I have therefore great pleasure in being in the chair to introduce him.

The following lecture, which was illustrated by lantern slides, was then delivered:

THE LECTURE

This year, the 350th anniversary of the first permanent colony of English settlers at Jamestown, Virginia, is being celebrated. After spending their first American winter in crude shelters, the Virginian settlers began to build houses of framed timber. By 1615 Jamestown could claim two fair rows of houses. Since then, in almost every corner of the world, builders from these islands—assisted by local men trained in their traditions—have been at work building houses, churches, schools, hospitals, factories, and the many other kinds of structure needed for a civilized way of life.

This talk is confined to building in the Commonwealth, and particularly in the colonial territories. In a year of important constitutional changes, it is opportune to review more than three centuries of British building overseas; to list some of its more recent achievements; and to consider the ways in which British builders can help development overseas in the coming years. (By builders, of course, I mean the whole industry of building with its associated professions—architects, engineers, surveyors—and its institutions for training and research.)

First, I propose to look at the earlier years of building particularly in those countries—Australia and India—which are now independent members of the Commonwealth. Then I will examine recent happenings, particularly in the fields of housing, educational building, and building for health and other social services. Here my attention will mainly be directed towards building in colonial territories. Because it is my special interest, I will devote rather more time to housing and the problem of orderly town growth than to other types of building activity.

Next I will examine the different ways in which building overseas has been influenced by and assisted from Britain: for example, by the introduction of building techniques, architectural methods and styles; by the employment of professional architects, engineers, and surveyors, and of building craftsmen; by the training of local people; and by commerce and trade. Again because it is my special interest, I will devote a little time to building research.

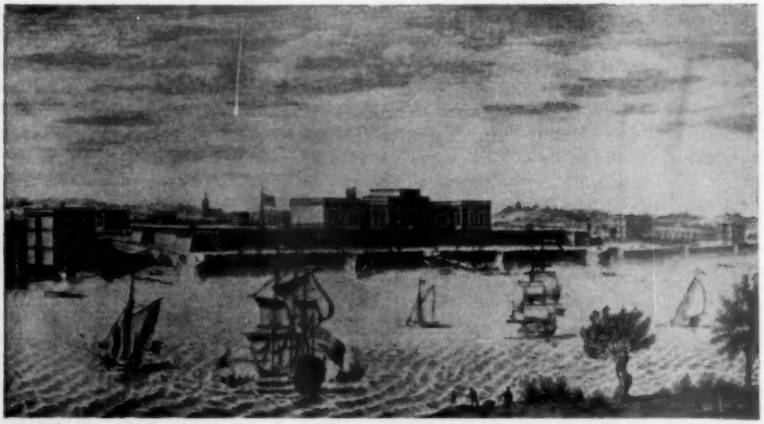

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FIGURE 1. *Calcutta: Old Fort William* (1754).
Largest of the trading forts of the East India Company

Finally, I will look at the present needs of building overseas; the ways in which Britain is helping to meet these needs; and how best this may be continued.

The first need of the colonists was for protection against the weather, and often against marauders. Dwellings, barracks for troops, stores and, on occasion, forts had to be built. Where, as in India and along the coast of West Africa trade was a main objective of settlement, the first buildings were fortified trading posts (Figure 1). Usually these early buildings were designed by military officers from the Artillery or, as the army became more specialized, the Engineers. Later, I will discuss further the important pioneer role military engineers have played in building in the Commonwealth.

In the early years of settlement, building was simple in character—for use

rather than ornament. Sometimes local materials—timber, mud, coral, stone, and so on—were used and local building traditions, where at all developed, followed. Often, however, materials and even ready-made buildings had to be imported. For example, Sydney's first hospital was a prefabricated building designed, it is said, by Jeffrey Wyattville, and brought out from England in 1790. During much of the nineteenth century sectional steel and timber buildings were being sent from Britain to Australia, the Cape, and wherever buildings were wanted urgently and at any price.

During the pioneer years, skilled builders and architects were usually lacking. Everyone—administrator, settler and trader—was his own builder. But, as the new settlements prospered, local building industries came into being. Craftsmen were attracted to the new settlements, or local men trained as carpenters, masons and bricklayers. Architects, engineers, and surveyors were employed on building and public works, in government service or a private capacity. Sawmills, brick kilns, lime works, and so on, were set up.

Sometimes, as, for example in the founding of Sydney, the local building industry developed quite rapidly. Conditions in New South Wales were favourable. Among the convict settlers were a number of building workers from Britain. They included a Bristol architect, Francis Greenway, who had been sentenced to transportation for forgery and had arrived in 1814 with a letter of introduction to Governor Macquarie. Macquarie, sent out a few years before to reorganize the convict settlement after Bligh's unfortunate government, was an enthusiast for public works. He found a ready and able assistant in Greenway, who soon was given his ticket-of-leave and appointed Government Architect and Assistant Engineer. In the next decade, Greenway laid out Sydney and built many of its early buildings in a competent Regency style.

When a Commissioner, J. T. Bigge, was sent out from England in 1819 to enquire into the affairs of New South Wales, Macquarie's lavish expenditure on public works was criticized. The Governor was recalled, but Greenway continued his work as Australia's first architect. The Bigge enquiry is of more than passing interest, for it highlights the problem of relating fine building to financial economy which can still bedevil building overseas. Too often, even to-day, over-optimistic programmes have been stopped dead, and second-rate buildings substituted for fine projects through a sudden demand for economy which, on later reflection, has seemed as unbalanced as the programme criticized. In recommending that

> the appointment of an officer of the Corps of Engineers . . . will be the means of introducing a more uniform and simple style of architecture into government work and preserving a more just proportion than has hitherto been observed between the execution and scale of the buildings and the actual and future resources of the colony

Bigge set a pattern for the conduct of public works which continued for most of the century.

The employment of engineer officers was not an innovation. In India they had been active builders throughout the eighteenth century. Detachments of

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FIGURE 2. *Calcutta: Government House* (1820). *Built to designs of Captain Wyatt, R.E., on the model of Kedleston*

the Corps of Military Artificers, commanded by engineers, were responsible for building in Gibraltar, Malta, the West Indies, and Canada, during the French wars. A company was even sent to St. Helena in 1816 to build a residence at Longwood for the defeated Napoleon.

Building overseas in the first half of the nineteenth century owed much to these military engineers. In the West Indies, Canada, Australia, on the West African Coast, in India and the Far East, they built bungalows, barracks and offices; organized convicts into useful gangs of road builders—even, as in Singapore, into builders of a cathedral and a government house. Later they were to open up communications and irrigate deserts. Some even became outstanding governors like Denison and, much later, Guggisberg (Figures 2 and 3).

These military engineers owed much to their principal teacher, Charles William Pasley (1780–1861). As a young officer serving in the Mediterranean and the Peninsular, Pasley had been impressed by the efficient French military works organization. In 1812, with Wellington's support, he got permission to establish a School of Military Engineering at Chatham, and for nearly thirty years directed it for the training of military engineers. Initially, the school's work was to teach military works. But, in 1825, Pasley also started a course in practical architecture for junior officers in the Corps who, in Pasley's words

> are often sent to the British Colonies soon after they enter His Majesty's Service and are there required to perform duties analogous to those of architects or civil engineers without having had any previous opportunity of acquiring a practical knowledge of the details of those duties.

I have mentioned Pasley and his Chatham-trained engineers at length, not only because the visible results of their work are still among the best buildings in many settlements overseas, but also because I believe there is much in common between Pasley's school at Chatham and my organization at Garston. Though not a teaching establishment, since 1950 we also have been running courses for architects and others in the service of government overseas. We have also given much assistance to the Department of Tropical Architecture, which the Architectural Association School in London started in 1955, and where young architects, including this year some half dozen from South-East Asia under the Colombo plan, can study tropical building under expert guidance.

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FIGURE 3. *Singapore: St. Andrew's Cathedral. Built in mid-nineteenth century with convict labour by Major McNair, R.E., the Colonial Engineer*

After about 1860, the quality and character of much overseas building fell noticeably. Government engineers, no longer Pasley-trained, were usually more interested in railways, roads and irrigation schemes than in building and this was particularly noticeable in India. Architects, where employed, seemed more concerned with the finer points of the Gothic revival than in practical building. In Australia, and later in Canada and South Africa, the rush for gold was on; the miners, when they stopped digging, wanted their buildings to be flashy. Railway stations, town halls, millionaire's mansions and cathedrals were, consequently, all too often decorated with wedding cake details.

In the first decade of this century, the philosophy of a new Imperial architecture was worked out in South Africa by Herbert Baker, under the influence of Cecil Rhodes. It was to reach its apogee at New Delhi. New Delhi and the work of Herbert Baker and his associates in South and East Africa remained the predominant influences on British architecture overseas almost to the outbreak of the Second World War. Not only had many of the architects in government service and private practice worked in Lutyens' or Baker's offices; but governments and private clients expected their supreme courts, secretariats, government houses and banks to be built as classical monuments (Figure 4).

However, in the early 1930s, two events occurred which, the one more and the other less directly, had a considerable effect on British building overseas.

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FIGURE 4. *Calcutta: Victoria Memorial Hall. An example of early twentieth-century implied classicism*

The first event—the economic crisis of the 'thirties—all but suffocated an infant New Delhi—Lusaka, the new Northern Rhodesia capital—and ended, or at least interrupted, the careers of many architects and engineers working overseas. It also led indirectly to appointment of the West India Royal Commission and to the concept of a United Kingdom Development and Welfare Fund, which was to have such an important influence on post-war building. The other event, unnoticed by most at the time, was the visit of the French architect, Le Corbusier, to Rio de Janeiro, to work with a number of young Brazilian architects on a new university. The resulting work, with its façade of sun-shading devices, was to have a profound effect on the style of tropical buildings almost everywhere.

Let us turn to the present day. Nearly £9 million of C.D. and W. Funds have been spent on higher education and it is perhaps natural that buildings for university education have been among the most impressive of the post-war schemes. At Ibadan in Nigeria, Maxwell Fry and Jane Drew have, since 1948, been building a new university college with halls of residence, an interesting library, and its large Trenchard Hall, seating nearly 1,000 people. Nearby a large teaching hospital designed by Watkins, Gray and Partners, in association with the Nigerian Federal Government's architects, is nearing completion. At Legon, just outside Accra, West Africa's second university is being built to designs of Harrison, Barnes and Hubbard.

To me perhaps the most satisfactory of these new universities, however, is the University College of the West Indies at Mona, near Kingston, Jamaica. Here the London architects, Norman and Dawbarn, have designed faculty buildings, halls of residence and teaching hospital, which echo in a simple contemporary manner the earlier traditions of the West Indies. A magnificent site and fine landscaping add greatly to the scheme's charm which, I understand, has been one of the most economical of the larger post-war building projects.

At Salisbury, Southern Rhodesia, local architects under the general guidance of Sir William Holford are designing the new University College of Rhodesia. Plans are under way for extending the University of Malaya to Kuala Lumpur. While in Hong Kong, Professor Gordon Brown has been adding a number of interesting buildings to Hong Kong University. Away from the main stream of overseas universities is the Chinese Nanyang University in Singapore, built at great speed in a variety of western and oriental styles.

In addition to these university buildings, there are two Colleges of Technology under construction in the Gold Coast and Nigeria, designed in the initial stages respectively by James Cubitt and Partners and the first head of the Nigerian School of Architecture, J. R. C. Rowell. In Kenya, the Royal Technical College, Nairobi, designed by Kenya government architects, is open. Further technical colleges are planned, for example, in Singapore and Kingston, Jamaica.

Educational building has not, of course, been confined to higher education. At all levels, from village school to teacher training college, new buildings are needed. Some are of the simplest character for it is difficult to provide more than a roof and a floor for £10 per child, the only money often available. More elaborate, of course, are the new secondary schools. Many are residential, and

often the cost of teaching space is only a small proportion of total cost in a scheme where housing may have to be provided for headmaster and kitchen hand.

Looking back on a very active period of school and university building, one realizes how much has been done despite difficulties, especially shortages in the immediate post-war years in materials and manpower. Naturally, standards have varied, so have costs; but, generally speaking, the achievements are something of which British builders overseas may be proud. Perhaps the less satisfactory work might have been improved and the more costly cheapened if there had been machinery for providing specialist information on school building and for studying the comparative costs of the often large building programmes involved. In England, the Ministry of Education has shown how useful such a service can be. The Ministry, increasingly, has been helping on aspects of school building overseas. Educational building is a field in which Britain leads, and I hope it may be possible to continue and, even, to extend this assistance in the future.

Next to schools, buildings for health services have possibly been among the more important projects overseas, at least in so far as C.D. and W. Funds are concerned. They vary greatly in scale from the teaching hospitals already mentioned and equally larger hospitals built or building, for example, in the Gold Coast, Trinidad, Hong Kong and Aden, to small rural dispensaries. Though at all levels there has been fine and interesting work, it is doubtful whether the building programmes as a whole have been as outstandingly successful as those for education. There may be a number of reasons for this. Architects find doctors notoriously difficult as clients. There has been little or no study of hospital and health building in the tropics. Many of the buildings, for reasons of financial economy, have had to be fitted into existing schemes which have been far from ideal. Recently, there are signs that the value of fairly long-term plans for the redevelopment of existing hospitals, a procedure often forced on English hospital boards through lack of money, is being more widely appreciated overseas.

It would take too long to describe the many other kinds of buildings which have been erected overseas by governments and private developments in recent years. They range from research laboratories and airport terminal buildings to police stations and magistrates courts; from luxury hotels to labourers' housing on rubber estates. Private enterprise, particularly in Nairobi, Singapore, Hong Kong and the Rhodesian towns, has changed the face of down-town areas and often greatly increased traffic and parking problems by building high blocks of offices and shops. At least equally as important has been industrial building.

Most people overseas still live under rural conditions: in circular huts of wattle-and-daub with grass roofs; in timber houses, some of considerable charm like the Malay house; in buildings of stone and sun-dried brick with flat or low-pitched roofs, following long-established Mediterranean traditions as in Cyprus. Occasionally they may just be squatters' shacks built of poles, sacking and scrap iron.

In only a few territories did large towns exist before the arrival of the European. In most, town life is a direct result of his enterprise and government. Frequently,

the towns started as trading posts through which, like Lagos, Mombasa, Singapore and Hong Kong, the produce of the hinterland passed on its way to the markets of the world. Sometimes, like Nairobi, Salisbury and Lusaka, they began as transport and administrative centres. Round these nuclei of European settlement, the local peoples and often traders from India, China, Arabia or the Middle East built their shops and houses. To begin with, at any rate, little was done to control what they did.

The story of Nairobi is typical. In the 1890s it had been decided to build a railway from the coast of Mombasa to Lake Victoria to connect Uganda with the sea. By 1899 the railway had reached Nairobi, a situation half-way between Mombasa and Kisumi, the terminal port on Lake Victoria. Ahead lay the hilly Kikuyu country and beyond a steep descent into the Great Rift Valley. It was an obvious site for a halt before tackling the next step in railway construction. The engineers, therefore, stopped to build up a railway headquarters, workshops and yards. Accommodation for the manual and low-grade salaried employees was sited on a flat strip of land adjoining the Athi Plain. An agreeable site on the foothills of the first Kikuyu escarpment was selected for the houses of the higher grades. Not for long, however, was Nairobi to remain a railway town. The civil administration soon saw the advantages of its location and moved in, as did the European and Asian traders.

Except in the railway reservations, there was little control over building. Sanitary conditions, especially in the Asian bazaar area, soon became atrocious. By 1901 the town had been visited by the plague; further outbreaks occurred in the years which followed. The disadvantages of the site, as well as its advantages became apparent. There was talk of moving to a more suitable location, but the new settlement was already too well established. By 1906 any idea of moving had been abandoned. Visiting Nairobi two years later, Winston Churchill wrote:

> It is now too late to change, and this lack of foresight and of a comprehensive view leaves its permanent imprint upon the countenance of a new country.

In 1913 following three severe outbreaks of plague in succession, Professor W. G. Simpson, a well-known sanitarian, was sent out by the Colonial Office to advise on Nairobi's problems. On his recommendation, a sanitary organization, building regulations and the elementary town planning scheme were established. It was a first step in the Kenya Government's direct concern with housing.

Elsewhere it was very much the same: an outbreak of plague; a visit by an eminent sanitarian—usually Professor Simpson; improvements in public health administration; the introduction of some form of building regulation and, possibly, the elements of town planning. Such measures undoubtedly did much to improve sanitary conditions, particularly in the centres of towns and in the wealthier residential areas. But they made little or no positive contribution to better housing. Indeed where, as often, the regulations were being copied from British legislation, building was made unnecessarily expensive. As a result, only the better paid could afford to build within the regulated areas. Those less well off were forced to overcrowd existing buildings, or to build outside the towns

where control was less strict or, more frequently, non-existent. This lack of balance in public health control over building may still be met with in a number of territories, though most are now bringing their regulations up to date. Some, like Uganda, are permitting simpler standards for housing in specially planned areas.

During the inter-war years, most governments, like other big employers, built houses for certain, at least, of their employees; in some territories, particularly in Africa and Malaya, the amount of housing undertaken was considerable. In East and Central Africa, where the towns were predominantly European, municipalities in addition might provide accommodation for migrant workers. Only on rare occasions, however, did governments take an active part in the improvement of general urban housing conditions.

The outbreak of the Second World War ended, temporarily at any rate, these first attempts at housing. It was only possible to carry out a few isolated schemes, like housing of dock workers at Takoradi, Gold Coast, and Mombasa. But, when planning for post-war reconstruction became possible, three events of importance occurred. The first event was the appointment, in 1943, of a Town Planning and Housing Adviser to the Development and Welfare Organization in the West Indies, an organization which had been recommended by the 1938–39 West India Royal Commission. The second, in November, 1943, was the preparation by the Colonial Office, for circulation to Colonial Governments, of a Paper: 'The General Aspects of the Housing Problem in the Colonial Empire'. The third was the appointment, in 1944, by the Colonial Office, in consultation with the Department of Scientific and Industrial Research, of an informal Study Group on Housing Research. As each of these events was to have some influence on post-war housing development, it is useful to examine them in greater detail.

The report of the West India Royal Commission left no doubt about the deplorable and insanitary condition of housing in many of the Caribbean territories. It recommended a wide programme of slum clearance and re-housing, administered by an expert staff and financed from a special West Indian Welfare Fund. In the event, after preliminary studies by the Adviser and his staff—which included the preparation of a handbook on West Indian housing—it was decided that town planners and architects should be appointed to the principal West Indian territories and the central organization be advisory rather than executive. Useful pioneer work was done and much valuable experience gained. Unfortunately, in the immediate post-war period, trained housing personnel proved difficult to recruit; building materials were also in short supply. Many of the housing schemes, therefore, proved costly; the standards adopted and the cost of building being beyond the means of the local peoples even when given considerable outside assistance. Looking back on this period, one might say that too much attention was given to rental housing and to the uneconomic clearance of slums in central areas; while too little attention was given to positive town planning, including the provision of developed sites for housing, to the organization of self-help owner-occupier housing schemes, to improved financing for

private house-building, and to increasing the general efficiency of the local building industries.

The second event, the 1943 paper on housing was, as far as I know, the first attempt by the Colonial Office to make a general review of this problem. It commented on the planning and organization of housing in the Colonies; on the provision of materials for house-building; and on housing finance. On its recommendation, housing committees were set up in a number of territories. C.D. and W. Funds were spent on pioneer housing schemes, for example in the Gold Coast, St. Helena, Tanganyika, Uganda and Zanzibar.

The third event was the most important for me personally. The Informal Study Group in Housing Research reported early in 1945. One of its principal recommendations was the establishment in Britain of a centre for the collection and dissemination of information on housing and building in the Colonies. This recommendation was accepted by the Colonial Office and, in agreement with the Department of Scientific and Industrial Research, an architect was appointed as Colonial Liaison Officer at the Building Research Station to organize the centre; his work being financed from the C.D. and W. Research Fund. I was fortunate enough to be selected for the post, and began work just eight and a half years ago.

In 1953 the widening functions of my work were recognized in my additional appointment as Housing Adviser to the Colonial Office. At the same time, the Secretary of State for the Colonies appointed a small advisory panel of experts in various aspects of housing, town planning and architecture. That similar assistance is also needed in other fields of building has been shown by the variety of subjects referred to my unit. They range from the construction of grain-storage pits to the design of mental hospitals and the equipment of post offices. Where necessary, specialist advice is sought from other sections of the Building Research Station or from elsewhere in the Department of Scientific and Industrial Research, or possibly from some organization like the General Post Office or the Ministry of Health.

During the last few years, much has happened in the field of housing overseas; in particular, one finds that government machinery for housing has been established, or is just coming into being, in most territories. Let us look at some of these developments. First, let us turn to the Eastern group of territories. Early in 1954 the Hong Kong Government enacted its first housing ordinance. This set up a Hong Kong Housing Authority to be financed from local funds. Level land for housing in Hong Kong is very scarce, land values are high and, consequently, all the housing has to be multi-storey (Figure 5). The Hong Kong Government has, therefore, decided that, while housing will be costed on an economic basis, grants will be made towards the cost of site preparation, and so on. The Government is also sponsoring cooperative housing schemes for locally recruited civil servants. In addition, it is undertaking a large squatter resettlement programme.

In the Federation of Malaya, where a portfolio of Local Government, Housing and Town Planning has been created, a non-profit making Housing Trust, established in 1950, began to function actively in 1953. The Trust has been

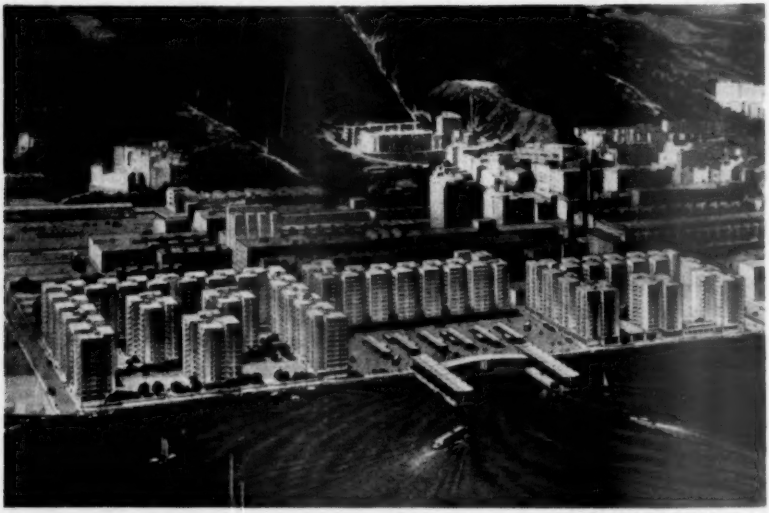

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FIGURE 5. *Hong Kong: North Point Scheme. Nine thousand people will be housed in the first of Hong Kong Housing Authority's large schemes, being built to designs of Eric Cumine, F.R.I.B.A.*

building houses for sale at Kuala Lumpur and elsewhere; it is about to undertake rental housing. Again, in Malaya there has been an extensive programme of resettlement; this has included the development of a new satellite community, with a total population of about 80,000, at Petaling Jaya, a few miles outside Kuala Lumpur. In Singapore, the Improvement Trust's work continues to expand (Figure 6); at present, new legislation is being prepared to bring the Trust's organization more in line with recent constitutional changes. In Singapore, Malaya and Borneo, a building society, financed initially by the Colonial Development Corporation, is providing a most useful service to house-owners. In Malaya, where it has received additional finance from the Federation Government, the Society has become the main source of mortgage finance for the purchasers of houses built by the Housing Trust, and by private enterprise.

Turning to East Africa, one meets again with a re-organization or strengthening of the government housing machinery in Kenya and Uganda. In Uganda, a separate African Housing Department was created in January, 1954. It has taken over from a special section of the Public Works Department which has been responsible for the construction of housing estates since 1948. In Kenya, where there is now an unofficial Minister for Local Government, Health and Housing, there has been an expansion of local authorities' housing activities. A large programme of housing is being undertaken in Nairobi jointly by the City Council and the Ministry.

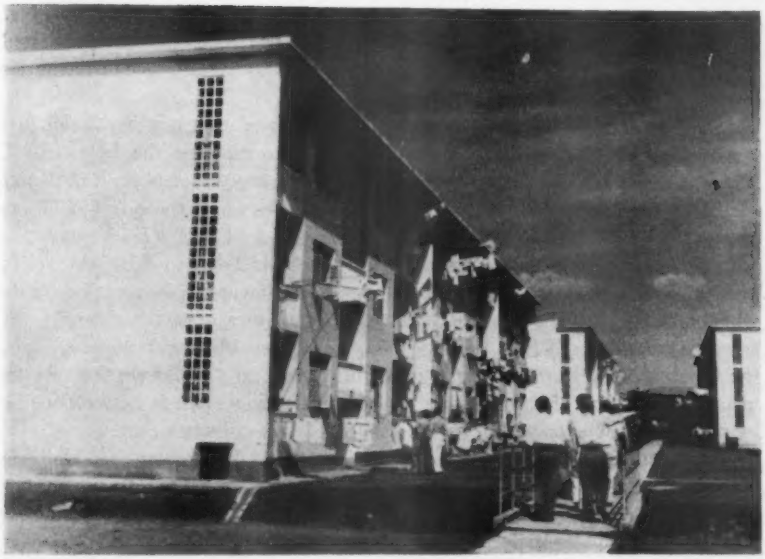

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FIGURE 6. *Singapore Improvement Trust flats. A view of the Alexandra Road housing estate, typical of present-day building for social services overseas*

Most active for some time of West African territories in the housing field has been the Gold Coast [now Ghana]. With the introduction of the 1951 Constitution, housing became a ministerial responsibility. In 1954–55 a United Nations Housing Mission visited the Gold Coast. On its advice, an autonomous Housing Corporation has been set up and has started a large programme of house building largely on sale on mortgage.

It is not possible in this paper to refer in detail to housing in the West Indies or Mediterranean territories or in the many small islands scattered through the Atlantic, Indian and Pacific Oceans. Most are undertaking housing schemes of one kind or the other. Some, like Cyprus and Barbados, have now established special organizations for housing.

Looking back over the post war period, the pattern along which housing is developing in the overseas territories is becoming increasingly clear. Much the same pattern can be seen in other countries like Ceylon, India and Pakistan, which face similar problems. First, it has now become widely accepted that the improvement of housing conditions is a continuing function of government. This does not, of course, mean that a government has an unrestricted obligation to build houses for every family at present badly housed; but rather that it has a responsibility, for example, to see that sufficient urban sites with reasonable services are available for those who want to build, and that available technical

and financial resources are mobilized in the most efficient manner possible. Consequently, housing is now usually a ministerial subject, often associated with local government and town planning, in the growing number of territories enjoying a measure of responsible government.

Secondly, it has become more generally appreciated that housing is not just a matter of clearing slums and building houses to rent for the less-well-off. There is rarely sufficient money for large scale clearance schemes; and measures for redevelopment, involving the eradication of the worst spots only and the improvement of the rest, on the lines first suggested by Patrick Geddes in India, may of necessity have to be followed. Again to build houses for all who are in need of shelter may well be beyond many governments' resources, especially when rents have to be subsidized as well. Other measures, for example the encouragement of self-help building and, for householders with some savings, the building by private enterprise or statutory authority of houses for sale on instalment may be able to make a major contribution towards better housing by mobilising the householders' own resources in cash or spare time.

Thirdly, more and more of those concerned with the problem are realizing the need for a fresh approach to housing standards. For example, it is now generally accepted that each family should have its own sanitary accommodation, however simple. Generally, single-room dwellings for a family are no longer acceptable, though in an emergency—as for example in the resettlement of Hong Kong's refugees—there may have to be a temporary relaxation. Where families live in their own houses in well laid out and administered schemes, considerable simplification in constructional standards is now being allowed by a number of governments—for example by Uganda—so as to encourage the self-builder.

Fourthly, recognition is increasingly being given to the social and economic value of encouraging home-ownership among families of moderate income. This often necessitates the development of new residential areas and large-scale house-building operations in order to reduce costs. Usually, government, through a statutory authority like the Malaya Housing Trust or the Gold Coast Housing Corporation, has to make the first move, but private enterprise can often take over once interest has been aroused. Side by side with estate development and house-building activities of building societies and other home savings and loans institutions need to be stimulated. The benefits such an activity can present by bringing into being a competent and enterprising house-building industry are more and more being understood.

Fifthly, the direct connection between housing and orderly town growth is becoming apparent as programmes get under way. The success of the Malayan new town, Petaling Jaya, compared with the difficulties usually experienced there and elsewhere in finding suitable urban land for housing at a reasonable price has, for example, shown the value of bold and well-planned schemes for town development.

Lastly, experience has shown that there is no magic solution to cheap building. This does not mean that there are no new technical innovations, materials and

methods of construction which can help to secure cheaper or better houses. But they are part of the general improvement of building. Progress depends mainly on raising the efficiency of local building industries on a broad front, or creating industries in territories where they hardly exist at present. Above all, it involves technical training to create better designers, managers and supervisors; craft training to produce more skilled operatives; research and development to improve local techniques and make more efficient use of the materials available, local or imported; and studies to rationalize contract procedures and the methods of financing building operations.

The lessons gained from housing apply largely to other forms of building as well. For example, the introduction of universal education in a number of territories is setting school builders similar problems. It necessitates a continuing programme of building rather than the construction of a haphazard series of single schools, each designed on a bespoke basis. Travelling school-building teams or regulated self-help building by the different communities needing schools may have to be organized if one is to avoid exhausting budgets long before needs are met. Again, as already mentioned in relation to hospital building, it is rarely possible to start from scratch and build to the design of the architect's or doctors' dreams. The funds available rarely permit this—the building of new teaching hospitals being among the few exceptions. But they may permit a radical redevelopment of an existing hospital in stages—pulling down some parts, altering others and rebuilding still others to a long-term development plan. Such a scheme calls for as much care, and more singleness of mind, than building afresh.

Equally with housing, progress with other forms of building depends above all on a more efficient building industry. Since the war builders from Britain have helped to secure this in almost every territory. First, a number of the larger contractors have set up subsidiary organizations overseas. Their work has done much to raise local technical standards. Without their efforts, the very considerable amount of building which has been completed could not have been done. Secondly, a substantial part of the materials and equipment used has been supplied from Britain. British firms have also helped to establish local industries: cement works in the West Indies, Nigeria, East and Central Africa, and Malaya; factories for asbestos cement roofing in Uganda and the Rhodesias; concrete tile works in Singapore—to name but three types of activity.

Architects, engineers and surveyors from Britain have also been responsible for a very large part of the building undertaken. Some are serving in government and local-government works organizations, or with statutory authorities. Others have gone overseas and set up local offices, a number in partnership with local-born colleagues. A few concerned with special projects have worked from Britain.

What of the future? As territories like Malaya and Ghana become independent members of the Commonwealth they will naturally be building for themselves increasingly, using their own architects, engineers and builders. But, in many spheres, cooperation with British builders is likely to continue; in some it may well be strengthened. Especially in Africa and the Caribbean, there will continue

to be work for British contractors, probably in association with local firms—in the Far East, most building is already being carried out by local contractors. Again, there is likely to be a need for many years for architects, engineers and surveyors, though in public service and, perhaps to a lesser degree, in private practice local men, as they complete their training, will increasingly take over the 'general practitioner's ' work.

The need for the experienced specialist—in housing, town planning, school building, hospital building, and so on—may well continue for a longer period. Indeed, a growing problem is how best to provide such specialist services. To some degree, as at present, they can be provided by the consultant engaged for a particular scheme; a new hospital, university, or tourist hotel. Frequently, however, governments want the continuing assistance of a specialist who may help them to evolve new building programmes, while training their own men to continue the work; this is particularly so in activities like town planning, housing and school building. More and more, such assignments will be for a period of years rather than for a career. Unless reliance is placed on 'free-lancing', some means of drawing on a pool of specialists may well have to be devised.

The usefulness of such pools for overseas development has for long been appreciated. The Corps of Engineers provided a very efficient pool of this kind in Pasley's time; one may regard the Overseas Service as a pool. But both tended to be pools of professional general practitioners rather than of specialists. It is the latter which may largely be needed in the future for building overseas, and other forms of organization may be found to be more suitable. Some, indeed, are already being tried out tentatively. For example, an architect from my unit has been helping, first, British Guiana and, later, Barbados, to start new housing ventures. Another form of organization being explored is the secondment of specialist from central or local government. It is no easy matter to work out an efficient yet flexible organization. But the demand exists and is growing; it comes not only from the colonial territories and other Commonwealth countries but, also, through United Nations Technical Assistance projects and the like, from other countries at a similar state of development.

One of the fields in which help from Britain is most needed in the immediate future is in that of professional and technical training. Until recently in the colonial territories local facilities for training were very limited. Possibly after preliminary teaching at a local technical school, the student of building or architecture had to continue his studies in Britain, Australia or Canada.

Now, schools of architecture and building are being set up in West and East Africa and the Far East. Though many of these schools are very young and they yet often only have a skeleton teaching staff, it looks as if, in the not so distant future, the larger territories will be well provided with facilities for training local men. The schools face many difficulties. First, there is the problem of recruiting experienced and enthusiastic teachers. Secondly, there is the problem of curricula and, closely linked, textbooks.

Building overseas differs from that in Britain in many ways. For example, the climate is often tropical; there are problems of hurricanes and earthquakes,

and attack by termites; building needs and the materials available to satisfy them are different. Since the Roorkee Manual, published a century ago, there have been few if any manuals written especially from the standpoint of building overseas. A number of the new schools are realizing that they have to help themselves by studying local ways of building and developing improved methods. To facilitate this, at the Kumasi College of Technology the Gold Coast Government is planning to set up a building development centre to work closely with the West African Building Research Institute at Accra. At Zaria, Northern Nigeria, a station of the Institute is to be set up adjoining the Nigerian College. Similar developments are likely in East Africa.

One of the tasks of my unit at the United Kingdom Research Station is to help such work by studying problems of tropical building and by interpreting the work of the station at Garston and of other Commonwealth research organizations, especially those in Australia, India and South Africa. It is encouraging to note that the setting up of facilities overseas has tended to increase the demands which we receive for advice and assistance. Though primarily concerned with the colonial territories, our contacts tend to widen.

In this talk, I have tried to show how considerable has been the contribution of these islands to building in the Commonwealth. It can continue to be on the same scale for many years though the emphasis is likely to change; for, in the future, it is in such specialist fields as town planning, low-cost housing, school and hospital building, building research, professional and technical training, the development of local building materials industries, large civil engineering works and, without doubt, the building of atomic energy stations that our contribution is likely to be most needed. Consultant and contractor have both an important role to play; so in many territories still will the salaried officer of government and statutory authority. But there is also likely to be an increasing need for specialists for limited periods of service, which might best be met either by organized secondment from building authorities in Britain or possibly some central pool. Finally, I believe that my unit at the Building Research Station and Colonial Office can continue to play a useful part largely by studying aspects of tropical building and by advising those overseas on their technical problems; but also by interpreting developments and conditions overseas to those concerned in Britain.

DISCUSSION

SIR SELWYN SELWYN-CLARKE, K.B.E., C.M.G., M.C., M.D., F.R.C.P. (Chairman, Commonwealth Section Committee): Early in his most constructive and interesting lecture Mr. Atkinson mentioned Sir Gordon Guggisberg as an outstanding example of one of the military engineers who later became a governor. Sir Gordon was the inspirer of the Prince of Wales College at Achimota and of Takoradi Harbour, both in the Gold Coast, and it is particularly appropriate that his name should be mentioned to-day because, as you know, on 6th March the Gold Coast will become a self-governing Dominion under the name of Ghana.

I should like to take up the cudgels on behalf of my professional brethren over Mr. Atkinson's reference to the difficulty architects always experience when

they have doctors as clients. I can truthfully claim that, in 31 years of service in Commonwealth territories, I experienced nothing but friendly co-operation with architects, whether they were government or privately employed. Nor can I agree with him that there has been little or no study of hospital and health buildings in the Colonies. In Hong Kong, for example, there was recently erected a very excellent maternity hospital of 200 beds. Long-term plans for hospital extensions in that Colony were evolved by a special committee of which I had the honour of being chairman in 1938. In the Second World War lack of funds and site difficulties combined to preclude as rapid development as would have been desirable.

I do agree most emphatically with the lecturer's criticism of the past tendency to copy too faithfully overseas building legislation in this country. When this was done, for example, in the case of the Housing and Town Planning Acts, they remained dead letters for years in some Colonies. They were far too elaborate. It is good to learn that, in Uganda for example, simpler standards for housing in specially-planned areas are being permitted. I am glad that Mr. Atkinson has referred to the importance of each family having its own sanitary accommodation; especially as I heard recently that some government-built village settlements with which I was connected some years ago in one of our Colonies were having this essential 'refinement', as it was called, omitted. I am pleased too to hear our lecturer mention that single-roomed dwellings are now tolerated as an emergency measure only. Such conditions are too often the prelude to a slum, and consequential ill-health to the occupants.

I hope that the lecturer's dream of a pool of experts on building in the Commonwealth tropical territories will be realized. As he clearly pointed out, this pool did, in fact, exist 100 years ago. Mr. Atkinson is to be warmly congratulated on the achievements already to the credit of his Building Research Station at Garston. I always derive much pleasure and profit from reading the *Colonial Building News* which he issues.

MR. J. N. C. HUBBARD: We, in Rhodesia, have a problem which is different from yours in that we are not content with merely conserving an interest in building; it is essential. I have been able to obtain information from the Building Centre here which has been exceptionally useful to me. When I do go back I will be able to talk in the technical terminology to contractors and the like. I do support the lecturer's statement that it is necessary. Although the tendency seems to be to rely too much on England in regard to the nature and types of buildings, we do need to look to this country very much to guide us in technical matters. I think that in itself is borne out by virtue of certain papers which I have seen. In Central Africa the country is growing tremendously. In three years I have never myself seen such a complete change of skyline as in Salisbury to-day. It is a completely modern approach to building, but nevertheless lectures of this kind, if they can be brought to us out there, will not only encourage our architects and our contractors and our manufacturers but they will also do a great deal of good. We do hope that Mr. Atkinson, when he comes to Rhodesia next time, will give us the benefit of the experience which he has obtained here through the Building Station: we do need this I can assure you.

SIR GILBERT RENNIE, G.B.E., K.C.M.G., M.C. (High Commissioner for the Federation of Rhodesia and Nyasaland): What has been remarkable, I think, in East and Central Africa in recent years has been the improvement in the standard of housing, especially for the African. If one compares the type of housing that is going up to-day with the type ten years ago, and especially with pre-war, one sees the most remarkable advance, and it has not yet come to an end. In the Copperbelt of Northern Rhodesia, some of the houses would be a credit to some of the better communities in this country.

There is tremendous need of housing in the rapidly-expanding industrial areas in

East and Central Africa. It is not only the great attraction of town life but also the expanding industries that draw Africans from the country and the town, and those new industries have somehow or other to find new housing for the Africans coming in. That has been a tremendous problem and in the Rhodesias we have, of course, benefited enormously from the professional and technical assistance from the United Kingdom.

Then there is the financial problem involved in all this. I think it is only fair to say that the credit squeeze in this country is actually having repercussions on the housing problems of some of the Colonial and other territories. They cannot find all the money they should.

As far back as 1947 I visited the Building Research Station and, as a result, I took away a copy of a pamphlet on how to cure smoking chimneys; that pamphlet was circulated widely in Northern Rhodesia and was of the greatest assistance to many a district officer who found that, after he had built a house, he had a smoking chimney.

MR. H. A. N. MEDD: I should like to ask Mr. Atkinson what kind of people live in that vast housing scheme on the sea-front at Hong Kong? The perspective drawing was in the Royal Academy last year. Are those flats for Europeanized people? Dense urban housing in industrialized cities was not mentioned in the lecture. Most big cities, I am speaking particularly of India, have suffered in the same way as we did here from what they call *Chauls* in Bombay. Now *Chauls* are piled-up boxes and the degree of slummery that exists in them has to be seen to be believed. Is anything being done towards solving the problem of dense urban lower-class housing? A lot of the things we see being built in Africa and in other Colonial territories are obviously only one- or two-storey houses, which is comparatively easy if there is space to do it.

THE LECTURER: The Hong Kong Housing Authority flats are for what I would call the better-paid artisans and salaried workers. They were originally for people earning up to about £400 a year, but I understand the limit for eligibility has since been increased to about £900 a year. The Housing Authority recognizes the risks involved in such high-density housing. Hong Kong has already had experience in managing similar housing belonging to the Model Housing Society, which employs a woman housing manager from Britain. The Housing Authority is concentrating on building up a good system of housing management; it recruited about a year and a half ago an experienced woman manager who had previously been responsible for the housing of Southend-on-Sea.

The Singapore Improvement Trust, which also owns large numbers of flats, has built up a commendable housing management service. During my visits to flats in Hong Kong and Singapore, I have always been impressed by how well the accommodation is kept. It is a tribute both to the management and householders. Undoubtedly, this country's specialist experience in housing management is one of the contributions we can make to development overseas.

MR. ROBERT SHAW: I noticed what I thought to be a tendency for most of the layouts shown to be based on a grid and I am rather interested to know how this came about. I suspect it was because of the methods of land survey where land is measured in large squares, but I feel this is a very limiting factor and is one which tends to make all housing areas look so very similar, and rather dull. This is not layout as we know it in this country, as has been shown so well in new towns here. I think we want to get away from grid layout in housing areas, which would make far more interesting, informal and pleasant places to live in.

THE LECTURER: It was accidental that I selected illustrations showing grid layouts.

There are many layouts following the topography of the site in a less formal manner. Some of these informal layouts are, however, artificial and are based on very low densities. I could have shown you illustrations of these where there has been excessive expenditure on roads and services as a result.

The layout which I showed of one of the new villages near Kuala Lumpur, laid out by the Federation of Malaya Town Planning Officer, was on a flat site. The rectangular—not grid—layout was more economical and practical. Where sites are flat and where, possibly, there are problems of land drainage as in British Guiana, such rectangular layouts may be necessary.

MRS. CECILY F. FORRESTER: Might I ask what part of British Guiana we were shown? I used to know Georgetown and most of it was below sea level, which is bad for building houses.

THE LECTURER: It was in Georgetown. It is true that Georgetown is mostly at sea level. Despite this, Georgetown is still the centre of population in British Guiana. Drainage and irrigation have been studied there and, as far as I know, there are no worries over flooding.

A vote of thanks to the Lecturer was carried with acclamation and, another having been accorded to the Chairman, the meeting then ended.

GENERAL NOTES

ROYAL ACADEMY SUMMER EXHIBITION

The Royal Academy rule that paintings in a one-man show may be hung in their Summer Exhibition almost seems like an act of cunning this year. The works of the wild men in Rooms VII and VIII (who caused such a sensation last year) are now so familiar to art addicts, that we feel these artists are already eating out of the hands of the traditionalists. Packets of corn flakes, babies in the raw, and adults with harsh, angular features that might have been painted with a shovel, are commonplaces. In the earlier rooms, the experimentalists now seem positively timid and tentative, beside men like the Spencer brothers, who have been full of drive for forty years.

The portraits are, on the whole, very disappointing. One of the few painters in this field, who have surpassed themselves, is Carel Weight, better known as an interpreter of the lighter side of suburban life. *Miss Orovida Pissarro* is a lively work, full of character, in which an indication of the sitter's own work is an adjunct, added by one sincere artist as a tribute to another.

Of the two portraits of royal sitters, that of the Duke af Gloucester, by Simon Elwes (who convinces us that he is also a fine painter of flowers) is much more satisfying than that of the Duke of Edinburgh by Annigoni, who has certainly not repeated the convincing ease that characterized his portrait of The Queen. Some sitters must prove much easier than others. Easiest in the show must have been *Harry Wheatcroft*, the famous rose grower, who has been relentlessly portrayed by A. R. Thomson, a painter who has vigorously invaded the realistic field of Stanley Spencer on this occasion. Two of the self-portraits are certainly not by self-worshippers, and two of art students suggest that students, even in their off time, can be of great value to portrait painters. Patrick Phillips has revealed his instinctive refinement in his grey *Student Resting*, and Derek Clarke's *Art Student* is organized abandonment, carried out under the influence of both traditionalists and experimentalists. In this respect, Clarke may well represent the academic mood for the next few years; since it is common knowledge that in the recent election, the contest between two candidates of opposing views was a dead heat, the casting

vote of the president being decisive, and suggesting that even-balanced painters may find the middle-of-the-road method most generally acceptable.

Even the old-fashioned story picture has not entirely disappeared. It has merely taken another guise. Indeed, the oldest of all human stories—that of *Paradise Lost*—is so flagrantly painted that it leaves little to the imagination; while the varied dexterity of John Ward shows that an instinctive draughtsman can hold activity in the grip of stillness so that we may appreciate the characters *In the Playground* with completeness.

The eagerness of Galleries VII and VIII, though not so tempestuous as that of last year, is immediately felt, the same group of young men mostly associated with the Royal College of Art and the Beaux Arts Gallery filling the bill. *Baby on a Striped Sheet*, by Derrick Greaves, so tiny and casually formed for the ordeal of life, that the golden field and suffused radiance of Lionel Bulmer's *Summer* might not be reassuring. *Venice* to James Fitton, is neither canals nor campaniles, but pink slices of water melon; and Peter Coker's *Apple Tree* has a fruitful integrity. Even the stern reality of *Liverpool: America Dock*, by that artist of our gloomier city quarters, Christopher Chamberlain, has a grim attraction. Ploughing a lonely furrow, Arthur Hackney is a superb disentangler of woodlands and undergrowth. His *Autumn Gleaning* is a new form of romance, the kind of pictorial quality that the wild life of the woods itself might appreciate.

Although there is a challenging figure of a man holding *The Raven* by Harry Phillips, and a moving figure of *The Risen Christ* by Josephina de Vasconcellos in the Central Hall, the sculpture, as a whole, is not very exciting. The president, Mr. Charles Wheeler, is in a restrained, classical mood with his study for a Manchester Cathedral group *Madonna and Child*, and Arnold Machin has a youthful *Fallen Angel* (of French spiritual origin) but the most exciting work is that hatcheted head of *Horace Brodzsky* by Gaudier-Brzeska, done more than forty years ago.

Jack Greaves catches a young girl leaning on a shelter rail, *Girl at Bus Stop*, and gives us a feeling of contemporary naturalness, as Sydney Harpley does with his concrete statue of *Barbara*. There is also the usual caseful of attractive trifles in terra-cotta, by Audrey Blackman, Marion Morris, Gladys Grimshaw, and others.

Water-colours are strongly traditional, Robert Austin and Russell Flint redeeming the academic approach and Pitchforth breathing a subtle life into the more experimental work, in a room otherwise lacking in excitement.

The exhibiting architects emphasize the adage that the more things change the more they remain the same. A very large proportion of the contemporary buildings are just as similar to one another as those in the cities that have grown up in the past couple of centuries or so. In the colder, mathematical age, light and space may be more available, but the buildings will not place any great strain in our æsthetic appreciation.

G. S. SANDILANDS

DESIGNS OF THE YEAR

At the invitation of the Council of Industrial Design the Faculty of Royal Designers for Industry appointed a panel of judges to select for their outstanding design 12 products from among some 3,500 which have been shown at the Design Centre, Haymarket, in the course of its first year. On 10th May His Royal Highness The Duke of Edinburgh presented certificates to the manufacturers of the products thus selected at the Design Centre, where the goods are now on view until 12th June.

The judges, Mr. Milner Gray, R.D.I., PP.S.I.A., Master of the Faculty (Chairman); Professor R. Y. Goodden, C.B.E., R.D.I., A.R.I.B.A., F.S.I.A.; Mr. Brian O'Rorke, R.A., R.D.I., F.R.I.B.A.; Professor R. D. Russell, R.D.I., F.S.I.A.;

and Mrs. Astrid Sampe, Hon.R.D.I., stress in their report that they were looking for examples of articles in common daily use and that for this reason they concentrated on simple and practical objects, component parts of the home rather than display pieces. They also sought to select goods from as wide a range of industries as possible, and the final selection includes examples of furniture, television, carpets, light fittings, textiles, wall-papers, heating equipment, cooking utensils, glass, pottery, cutlery and plastics.

FROM THE JOURNAL OF 1857

VOLUME V. 22*nd May*, 1857

SUPERSTITION

From a paper on The Brussels Congress of 1856 and its bearing on the progress of international commerce.

The disinclination of our forefathers to cultivate hemp, or as they spelt it *Hempe*, gave rise to a curious distich, 'when hempe is spun England's done'. Lord Bacon notices this popular saying, which afterwards became a prophecy in ages of superstition. This prophecy was supposed to have been fulfilled at the accession of James I, by the decease of all the sovereigns whose names began with those ominous letters, viz., Henry 8, Edward 6, Mary, Philip (her Spanish husband), and Elizabeth. When they had expired 'England was done' of course, because James was a Scotch king. This is another specimen of the 'wisdom of our ancestors'. It is astonishing to think how often England has been 'done', ruined past hope and help; and yet we somehow mange to get on, and to look each other in the face with much apparent satisfaction.

Some Activities of Other Societies and Organizations

MEETINGS

TUES. 28 MAY. Courtauld Institute of Art, 20 Portman Square, W.1. 5.30 p.m. Dr. C. de Azevedo : *Portuguese country houses.*

International Affairs, Royal Institute of, 10 St. James's Square, S.W.1. 1.30 p.m. Jacques Soustelle : *The Algerian tragedy and the problems of Africa and the Middle East.*

William Morris Society, at the Art Workers' Guild, 6 Queen Square, W.C.1. 7.30 p.m. R. Furneaux Jordan : *The medieval vision of Morris.*

THURS. 30 MAY. Anthropological Institute, Royal, 21 Bedford Square, W.C.1. 7.30 p.m. D. Rycroft : *African music in Johannesburg.*

FRI. 31 MAY. Physics, the Institute of, at the Royal Society of Arts, W.C.2. 3.30 p.m. Dr. A. C. Menzies : *Symposium on electric detection in spectroscopy.*

MON. 3 JUNE. Geographical Society, Royal, Kensington Gore, S.W.7. 5.0 p.m. D. L. Botting : *Oxford expedition to Socotra.*

THURS. 6 JUNE. Anthropological Institute, Royal, 21 Bedford Square, W.C.1. 5.30 p.m. Professor F. Zeuner : *Palæolithic industry and racial problems in Western Asia.*

WED. 19 JUNE. Visual Education, Council for, at the Housing Centre, 13 Suffolk Street, S.W.1. 3.0 p.m. Fourteenth annual meeting. H. Morris : *Style maketh man.*

OTHER ACTIVITIES

NOW UNTIL SUN. 26 MAY. Exhibition of paintings from the Solomon R. Guggenheim Museum, New York, at the Tate Gallery, Millbank, S.W.1.

NOW UNTIL FRI. 31 MAY. Royal Society of Health, 90 Buckingham Palace Road, S.W.1. Exhibition : *Atoms and health.*

NOW UNTIL SAT. 31 AUG. Horniman Museum, London Road, Forest Hill, S.E.23. *Exhibition of Rumanian folk art.*